

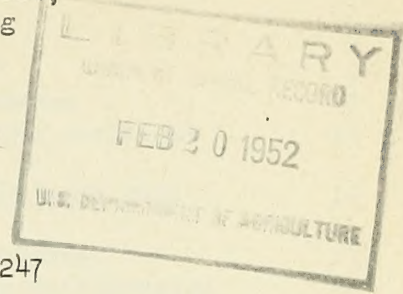
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✓ The Shelf Life of Fresh Fruits and  
Vegetables in Retail Store Display Cases ✕

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# The Shelf Life of Fresh Fruits and Vegetables in Retail Store Display Cases

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## Introduction

This is a progress report of studies which are being conducted to determine the effects of retail store display and handling practices upon the quality and condition of fruits and vegetables, not only while still in the hands of the retailer but also after a reasonable time in the hands of the consumer.

It is recognized that the primary interest of the retailer is to sell the produce as quickly as possible. Sometimes it is necessary to hold produce for several days, especially in the smaller stores, and its life in the hands of the consumer is appreciably shortened. Such produce may appear fairly satisfactory in the display case but show considerable deterioration soon after purchase by the consumer. Whether or not the consumer will use fruits and vegetables in the fresh state undoubtedly depends largely upon such important factors as costs, appearance, wastage, flavor, and their nutritional value.

The shelf life of fresh fruits and vegetables depends upon several factors, some of which are the previous history of the produce, its freshness, and its general quality when received at the retail store. At the retail store, aging, wilting, decay, or other deterioration processes progress more or less rapidly, depending upon the handling practices followed with regard to temperature and moisture.

Respiration and other physiological changes take place throughout the life of fresh fruits and vegetables. In the process of respiration, heat is generated which in turn causes a further increase in the rate of respiration. Cooling of the produce will reduce the rate of respiration, slow down aging, and retard the development of decay.

Retail store operators follow various handling practices to control temperatures of fresh fruits and vegetables. The mechanically refrigerated case and the ice bed case are used to maintain cool temperatures during both day and night, while in some stores the produce is displayed in non-refrigerated cases during the daytime and held overnight in "walk-in coolers" or in iced produce barrels.

In order to study changes in the shelf life of fruits and vegetables with various methods of handling, a laboratory at Beltsville, Maryland, has been equipped with several types of display cases which are operated to simulate certain retail store conditions. Studies of changes in the quality of different kinds of produce are being conducted with varying temperature and moisture conditions. These tests should be repeated a number of times with produce from various sections of the country, and at different seasons of the year before definite conclusions can be reached. However, preliminary information regarding temperatures and changes in the quality of some produce under certain specific conditions are discussed in this report.

In evaluating the results, it is well to keep in mind that the previous history of the produce has a very important effect upon its shelf life. Produce marketed at the peak of its season should remain in good condition longer than that which has been harvested at the end of the growing season. Rapid deterioration



may be expected in produce that has been exposed to extreme temperatures before reaching the retailer. Delays in moving produce through jobbers' hands, a common and sometimes unavoidable situation, often results in shortened shelf life of fruits and vegetables. Rough handling causes injuries which accelerate deterioration of the produce regardless of the best retail store handling practices.

The data given in this report cover only the effect of temperature and moisture under the conditions stated, and with the equipment specified. It is obvious that results obtained with the same commodities may show some variations from those secured in these studies because of differences in quality of produce, variations in temperature and moisture conditions with different types of equipment, and physical handling of produce while on display in stores.

### Summary and Conclusions

The shelf life of ~~nine~~ different vegetables was studied under various methods of handling in retail store display cases. The produce was displayed for several days in non-refrigerated, mechanically refrigerated, and ice bed cases. The vegetables were subjected to the following handling practices:

1. Displayed in a non-refrigerated case during the daytime and stored in an iced produce barrel, and in 32°, 40°, or 50° F. "walk-in coolers" at night.
2. Displayed on a false bottom rack and on the regular rack in a mechanically refrigerated case.
3. Displayed in an ice bed case.

In each display case, one lot was sprinkled several times daily and a duplicate lot was not sprinkled at any time. In the ice-bed case, one lot was garnished with crushed ice several times daily, and two lots were garnished only at night when the produce was prepared for night storage. Of the latter two lots, one was sprinkled and the other was not sprinkled although the produce became wet from the garnish ice that melted during the night.

A treatment whereby no refrigeration was employed was not included because such a method of handling highly perishable vegetables cannot be recommended under any circumstances. Even if no equipment is available for daytime refrigeration, overnight storage in "walk-in coolers" or in iced produce barrels is recommended for extending the shelf life of produce and to help preserve its nutritional value.

The position of produce in the display cases affected its temperature. Produce displayed above the top front edge of the cases were appreciably warmer than produce in the lower layers. Produce displayed on the false bottom rack in the mechanically refrigerated case was considerably higher in temperature than produce displayed on the regular rack, and became unattractive as much as 2 days sooner. False bottom racks should not be used in refrigerated cases if the benefits of refrigeration are expected.



Night refrigeration resulted in average daytime produce temperatures in a non-refrigerated case which were considerably lower than the average display room air temperatures. During 13 separate tests in which produce was stored at night in iced produce barrels or in a 40°F. "walk-in cooler", the average daytime produce temperature was 17 degrees lower than the average daytime room temperature. The 24-hour produce temperatures averaged 24 degrees below the average display room temperature for the same period.

Changes in the temperatures of produce when exposed to different air temperatures were more rapid in leafy vegetables than in solid commodities such as apples and cucumbers.

No appreciable differences were found in the temperatures or condition of produce that had been stored in the metal and in the wood produce barrels at night after being exposed to daytime room air temperatures in retail store display cases. Night temperatures of the produce in the iced produce barrels were appreciably lower in the center than near the sides of the barrels.

Of 37 separate treatments in the produce barrels, the produce in 36 of them had gained in weight.

Practically all of the produce that had been displayed on a bed of crushed ice, whether garnished several times daily or garnished only at night remained attractive for 2 days whether sprinkled or not sprinkled. The produce which had been sprinkled several times daily and garnished only at night, and that which had been garnished several times daily gained in weight due to moisture absorption.

Sprinkling with tap water four times daily had no cooling effect upon the produce, but it kept the produce attractive longer and reduced moisture loss. In 54 paired lots of sprinkled and non-sprinkled produce, 10 of the sprinkled lots were attractive a day longer than the non-sprinkled produce and 5 were attractive 2 days longer. Moisture loss in non-sprinkled produce averaged approximately 3, 6, and 8 percent, whereas sprinkled produce gained an average of 1 percent in weight during the 3-day test periods.

Snap Beans. Refrigeration and sprinkling prolonged the shelf life of the beans used in these tests. Snap beans do not require as low temperatures as most other produce. Night refrigeration in storage rooms held at 40° to 50°F. is satisfactory after daytime display in non-refrigerated display cases. Sprinkling several times daily kept the snap beans crisp and tender.

The principal defects that developed in snap beans during the 3-day tests were drying and flabbiness, a fading of the green color, and russetting of the pods. In most tests, the beans remained in good condition under all methods of handling and were attractive throughout the 3-day tests. In the non-sprinkled lots in all display cases some beans became dry and flabby, and lost considerable weight due to moisture evaporation. Decay was of no importance. No russetting was present in any lot after two days, and only one of 6 lots tested under similar conditions of temperature and moisture showed russetting after three days.



Beets, bunched. Refrigeration and light sprinkling prolonged the shelf life of bunched beets. Heavy wetting of the leaves should be avoided especially at high temperatures as excessive moisture provides a favorable condition for the development of decay of the leaves. Light sprinkling of the beets in the upper layers prevented wilting of the leaves and sponginess of the roots during each of the 3-day tests.

If daytime refrigeration is not available as mechanically refrigerated or ice-bed cases, bunched beets should be stored at night in a "walk-in cooler" or in an iced produce barrel.

Italian Sprouting Broccoli. These tests demonstrate the importance of refrigeration together with sprinkling with water to secure maximum shelf life of broccoli. Without refrigeration, only one day's shelf life in the retail store can be expected. With refrigeration from a mechanically cooled case or ice-bed rack, 2 or 3 days shelf life is assured if the broccoli is kept moist through sprinkling or garnishing with ice.

If daytime refrigeration is not available, night refrigeration should be furnished either in a cold room or iced produce barrel. If no refrigeration during day or night can be given, sprinkling is not recommended because the moisture it furnishes together with the high produce temperature (above 55° F.) makes favorable conditions for the development of decay.

Condition and quality of the broccoli at the time it is displayed for sale are very important in determining its marketable period. The chief defects which occur are yellowing, wilting, and decay of the buds with consequent off-odors. Least discoloration of the buds in these tests occurred in broccoli displayed on an ice-bed and kept garnished with crushed ice several times daily.

Carrots, bunched. Variable conditions of the carrots when received from the wholesale produce market caused some variations in the results obtained in the tests. Some lots were attractive when removed from the original containers whereas others were unattractive due to the presence of yellow and discolored leaves and shriveled roots. The principal defects that developed under the various handling practices were flabbiness, shriveling, and discoloration of the roots and yellow and discolored leaves. These defects were most common in carrots that were not sprinkled. The percentage of such defects was especially high in carrots displayed on the false bottom rack in the mechanically refrigerated case. Sprinkling and low temperatures prolonged the shelf life of carrots by preserving a fresh appearance of the leaves and firmness of the roots. Light sprinkling gave better results than heavy wetting which caused a dark, watersoaked appearance of the leaves. Results indicate that sprinkling was more beneficial than low temperatures although both are highly desirable. If daytime refrigeration in a mechanically refrigerated or ice-bed case is not available, night refrigeration should be furnished in a cold room or in an iced produce barrel.

Cauliflower. Spotting of the curds and wilting of the leaves and curds were the only important defects that developed during the 3-day tests. Decay, and yellowing of the leaves were of little if any importance. Variations occurred in the tests which were probably due to some growing or handling condition previous to the time the cauliflower was obtained from the wholesale produce market. The cauliflower in all display cases remained attractive for one day. At the end of the second and third days, there was considerable variation in the attractiveness of the cauliflower that had been treated in a similar manner during the different



testing periods. Sprinkling and low temperatures prolonged the shelf life of cauliflower. At produce temperatures above 50°F. more spotting occurred in the sprinkled lots than in the non-sprinkled. Spotting was most prevalent in the non-refrigerated case and on the false bottom rack in the mechanically refrigerated case. More wilting and greater weight losses occurred in cauliflower that had not been sprinkled than in the sprinkled or garnished lots. Night storage at temperatures of 40°F. or lower and sprinkling several times daily will prolong the shelf life and reduce weight losses.

Cucumbers. No appreciable differences were found in the shelf life of cucumbers under any of the various handling practices during the 3-day tests in the display cases. However, cucumbers that had been stored for a week or more in "walk-in coolers" with high humidity showed more rapid deterioration at temperatures of 40°F. and lower than at 50°. This deterioration was due to the development of numerous pitted areas which decayed when the cucumbers were exposed to room temperatures for one or two days.

The principal defects that developed in the cucumbers displayed under varying conditions were shriveled and soft ends. These defects were found under all handling practices. Some yellowing occurred in both sprinkled and non-sprinkled cucumbers in one lot that showed signs of aging when they were obtained from the wholesale produce market. No yellowing occurred in any other lot during the 3-day tests. Practically no decay developed under any of the various handling methods.

Lettuce, Iceberg. Refrigeration and sprinkling the lettuce several times daily prolonged the shelf life of lettuce. Loss of quality, size, and weight of the heads was caused principally by loose leaves that became detached in ordinary handling and by leaves withered from excessive moisture evaporation. The greatest total weight losses were found in lettuce that had not been sprinkled. Lettuce under all methods of handling remained attractive for one day without reconditioning. After the second and third days, trimming of broken, torn, and loose leaves in most of the sprinkled lots and withered leaves in the non-sprinkled lots was necessary to improve the appearance of the heads. Decay was of no importance except in one lot of sprinkled lettuce displayed for three days on the false bottom rack in the mechanically refrigerated case.

Onions, Green. High temperatures accelerate and low temperatures retard the development of yellow and decayed leaves. Refrigeration and sprinkling prolong the shelf life of green onions by preserving a fresh, attractive appearance. Onions whose average temperatures were 40° to 50°F. remained attractive for three days while those averaging 55° to 65° became unattractive because of yellow leaves. At the higher temperatures, sprinkled onions showed somewhat more decay than those that had not been sprinkled. Sprinkling several times daily and night storage temperatures of 40°F. or lower when daytime refrigeration is not available, are recommended.

Radishes, Bunched. The previous history of the radishes before reaching the retailer appears to have a greater effect upon their shelf life than the method of handling commonly practiced by store operators. Some lots became yellow, slimy, and unattractive after one day, whereas other lots remained attractive throughout the 3-day tests under similar condition of temperature and moisture.

Sprinkling several times daily resulted in the roots remaining firm and crisp while the non-sprinkled roots became flabby or spongy. Sprinkling also reduced yellowing and wilting or withering of the leaves. No appreciable differences in the occurrence of decay were found between the sprinkled and the non-sprinkled radishes.

Average produce temperatures as high as 60° F. did not materially affect the appearance of the radishes during the first day under any of the methods of handling but after three days a much larger proportion of the lots with produce temperatures below 45° were attractive than of those held at higher temperatures.

If daytime refrigeration is not available in a mechanically refrigerated or ice-bed case, bunched radishes should be kept overnight in an iced produce barrel or in a "walk-in cooler" held at temperatures of 40° F. or lower.

The results of the tests reported herein indicate that rapid deterioration of produce in the hands of both retailer and consumer is sometimes due to the poor condition of the produce when it is received by the retailer. The shelf life of produce in retail stores is materially shortened when produce has been improperly handled in transit or has been held without refrigeration for several days in wholesale or jobber sales rooms. Under such conditions the package ice often becomes melted and the produce temperature rises. The higher temperatures, together with moisture from the melted ice, provide ideal conditions for the development of decay. Broken, and bruised produce also deteriorates rapidly. Better refrigeration and handling practices would do much toward reducing deterioration of produce.

#### Suggestions for Prolonging the Shelf Life of Fresh Produce

Produce should be moved as quickly as possible through the various marketing channels from shipping point to the consumer. Such highly perishable commodities as broccoli, radishes, green onions, leafy vegetables, etc., should be kept well refrigerated in order to retard aging, discoloration, decay, or other deterioration which may cause consumer dissatisfaction with the quality of produce offered in retail stores.

Light sprinkling with water several times daily will reduce wilting and prolong the shelf life of most vegetables.

Produce that has been displayed in non-refrigerated cases during the daytime should be stored at night in iced produce barrels or in refrigerated storage rooms.

Produce should not be piled above the top front edge of refrigerated cases unless it is expected to be sold in a reasonably short time.

Produce that requires good refrigeration should not be displayed on false bottom racks in mechanically refrigerated cases.



### Equipment and Methods

The following equipment was used in the various tests covered in this report:

Display cases. A 6-foot non-refrigerated wood display case with galvanized metal bottom and sides was used. The case was provided with a slatted rack sloping from 8 inches above the bottom at the back of the case to 1 inch at the front. The top front edge of the case was 10 inches and the back 32 inches above the bottom. The top of the case extended 13 inches from the back toward the front.

A 10-foot commercial, mechanically refrigerated display case (convection type) with mirror back was also employed. The distance from the front to the back of the case was approximately 3 feet. The regular rack which was provided with the case was 3 inches above the bottom at the front and was 5 inches from the bottom at the back of the case. The top front edge of the case was 9 inches above the rack. A false bottom rack was constructed for use in certain tests in the mechanically refrigerated case. One-quarter inch mesh wire screen was used as the bottom of the false rack which was about 7 inches above the regular rack and 2 inches below the top front edge of the case. A solid partition was used to separate produce on the regular rack from that on the false bottom.

A 5-foot insulated commercial ice bed case with mirror back, metal sides and sloping bottom was the third type of case used. A drain was provided to carry off water from the melting ice. The case measured approximately 27 inches from the front to the back. The depth at the front was 11 inches from the bottom to the top edge, and at the back was 8 inches from the bottom to the lower edge of the mirror. In each of the tests, 3 to 5 inches of crushed ice was spread over the bottom before the produce was placed in the case. This bed of ice was replenished once each day during the various tests.

In the "garnished" treatments, a thin layer of crushed ice was spread over the produce soon after the ice bed had been replenished in the morning; the produce was again garnished with thin layers at noon, and at mid-afternoon. At six o'clock at night a thick layer of ice was spread over the produce which was then covered with heavy paper. The produce remained covered until the following morning when it was prepared for daytime display. Crushed ice (chestnut size) was used in the tests and was stored in a 16° F. room until needed. Before using in the ice bed case or in the produce barrels it was held in the display room until its temperature was about 30° F.

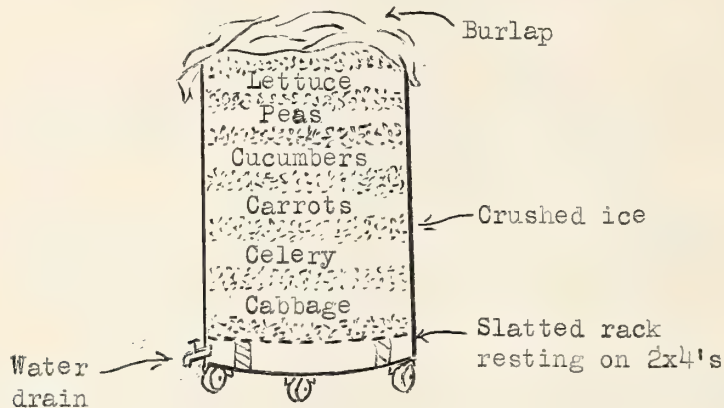
Produce barrels. Two types of produce barrels of about 50 gallon size were used. One was a metal drum with sides approximately 1/20 inch thick, and the other was an oak barrel with sides 3/4 inch thick. The barrels were provided with drain spouts and slatted false bottom racks resting on 2 x 4 inch wood blocks.

Before packing produce in the barrels, 2 or 3 inches of crushed ice was spread on the slatted rack. Alternate layers of vegetables and ice were then placed in the barrels. About 12 pounds of ice was used in the bottom, 6 pounds between layers of produce and 12 pounds over the top layer of vegetables. The barrels were then covered with a wet burlap sack and left overnight in the display room.

About 60 pounds of ice were usually used each night in the produce barrel. When the produce was removed in the morning, 2 or 3 pounds of ice generally remained in the barrel.

A sketch of a packed produce barrel is shown below.

Fig 1. THE PRODUCE BARREL. Vegetables packed in alternate layers with crushed ice for night storage.



Cold storage rooms. A 32°, 40°, and a 50° F. storage room, each of which was 9 feet high, 9 feet wide, and 15 feet long were available for the tests. The temperatures in these rooms were thermostatically controlled, and small fans were used to provide circulation of air. The relative humidity was kept at approximately 85 percent. Produce other than that used in the tests was also stored in the rooms.

Display room. The display cases were set up in a room on the ground floor of a well insulated brick building. Temperature records taken at the top of each display case and near the entrance to the room were within 4 degrees of each other at all times and about 90 percent of the time did not vary more than 2 degrees. Average room temperatures during each of the various tests ranged from 72° to 90° F, usually 72° to 75°.

Temperature records. Fruit thermometers were used to take commodity temperatures where they could be easily and quickly read and temperatures of produce located in such inaccessible places as in the produce barrel, or in the bottom layers of produce in display cases were obtained with thermocouples. Recording thermometers were used for securing a continuous record of day and night temperatures of produce and hygrothermographs were used to make continuous recordings of temperature and humidity in the display room.

Sprinkling. A watering can, and a half-pint size bulb-type rubber water sprayer were used to sprinkle the produce with tap water.

Moisture changes. The difference between the original weight of the produce and that found at the end of each testing period is reported as "moisture" loss or gain although it is recognized that a minor part of the difference is caused by respiration.



Operation of the display room. Practically all of the produce used in the tests was obtained in original containers from dealers on the Washington, D. C. wholesale fruit and vegetable market. It was hauled in a covered truck for fifteen miles to the U. S. Bureau of Plant Industry Station at Beltsville, Maryland, and immediately placed in a refrigerated storage room where it was held until each of the commodities had been sorted into representative samples for the tests. In selecting samples, size as well as other quality and condition factors were considered. Decayed, discolored, or otherwise objectionable specimens were either trimmed or discarded.

The display room day began between 8:00 A.M. and 9:00 A.M. when the produce was arranged on the racks, and it ended when the produce was prepared for night storage between 6:00 P.M. and 7:00 P.M.

The produce used in the mechanically refrigerated and in the ice bed cases were held in these cases throughout the entire tests except for the time necessary to weigh each specimen and examine it for changes that may have occurred during the previous 24-hour period. The produce in these cases was covered with heavy paper at night. Produce in the non-refrigerated case was removed each night to the refrigerated storage rooms, or packed in produce barrels which were left in the display room during the night.

Fruit thermometers, thermocouples, and recording thermometers were kept in the same relative positions in the produce throughout the tests.

### Results

#### Effect of Position in Display Cases Upon the Temperatures of Produce

Results of various tests clearly show that temperatures of fruits and vegetables are materially affected by their positions in display cases and by the depth from the bottom to the top of the produce (figs. 2, 3, & 4). Lower temperatures were found in produce in the bottom layers than in the top layers in all display cases, the extent of the variations depending upon the depth of the produce.

In the non-refrigerated case, the lower temperatures in the bottom layer were apparently due to the insulating effect of the upper layers which preserved the low temperatures resulting from refrigeration in the holding room overnight.

In the ice bed case, the temperature of the top layer of produce displayed 9, 12, and 15 inches deep averaged 14, 24, and 29 degrees, respectively, higher than in the bottom layer.

In the mechanically refrigerated case, temperatures of produce displayed 9, 12, and 15 inches deep averaged 16, 21, and 27 degrees, respectively, higher in the top than in the bottom layer.

The distance between the source of refrigeration and the produce cases had an important effect upon the temperature of the produce and the produce. This is illustrated by results obtained from several tests made with produce displayed on a false bottom rack and on the regular rack provided with the mechanically refrigerated case (see table 1). The produce in each sample extended from the front to the back of the rack.

The average temperatures of the vegetables in 22 paired lots displayed on the false bottom rack ranged from 55° to 64° and averaged 58° F. Whereas on the regular rack the average temperatures ranged from 38° to 53° and averaged 43° F. The temperature of the produce on the false bottom rack averaged 15 degrees higher than on the regular rack.

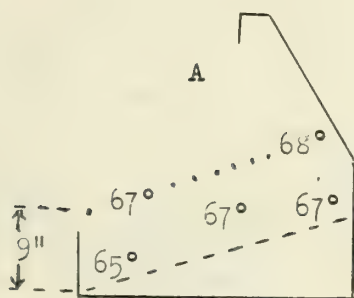


Fig. 2. Effect of Position Upon Temperatures of Produce Displayed in Non-Refrigerated Case

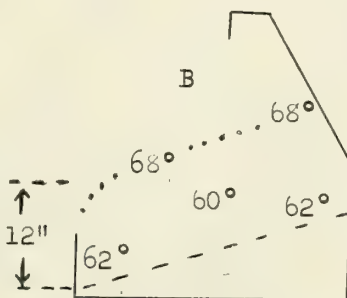
Temperatures at various positions in the display case are shown in the cross-section diagrams below. The temperatures are averages of 12 to 17 daytime readings at each position over a period of 4 to 5 days.

The depth of produce on the racks is indicated at the left of each diagram.

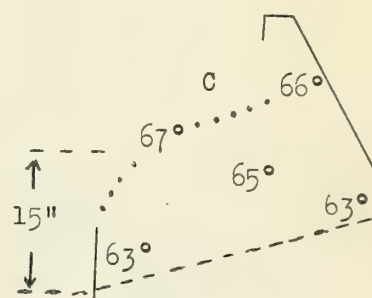
The dotted line from the front to the back of each case indicates the top of the produce.



LETTUCE



BUNCHED CARROTS



CABBAGE

On non-refrigerated rack during daytime and in 45° to 50°F. room at night. Display room air temperature 82° to 86°, averaging 84°F.

On non-refrigerated rack during daytime and in 45° to 50°F. room at night. Display room air temperatures 75° to 81°, averaging 78°F.

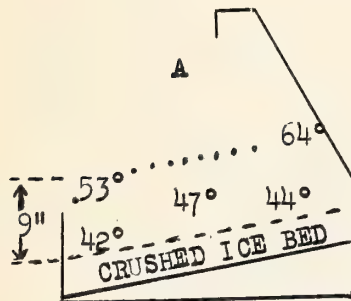
On non-refrigerated rack during daytime and in 45° to 50°F. room at night. Display room air temperatures 80° to 84°, averaging 82°F.

Fig. 3. Effect of Position Upon Temperatures of Produce Displayed in Ice Bed Case

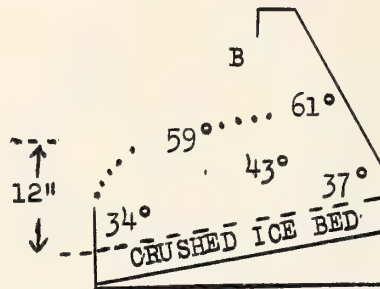
Temperatures at various positions in the display case are shown in the cross-section diagrams below. The temperatures are averages of 12 to 17 daytime readings at each position over a period of 4 to 5 days.

The depth of produce on the racks is indicated at the left of each diagram.

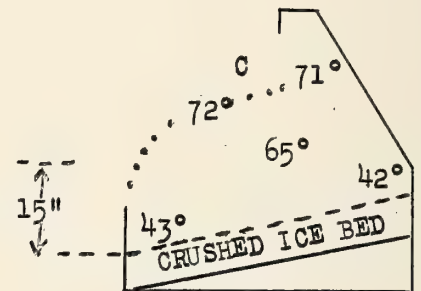
The dotted line from the front to the back of each case indicates the top of the produce.



LETTUCE  
Room temperatures  
82° to 86°, av. 84°F.



BUNCHED CARROTS  
Room temperatures  
75° to 81°, av. 78°F.



CABBAGE  
Room temperatures  
80° to 84°, av. 82°F.

The produce was arranged on a bed of crushed ice which was 3 to 5 inches deep; it was garnished with a thin layer of crushed ice 3 times during the daytime and a thick layer was applied when the produce was prepared for night storage. The produce was covered with heavy paper during the night.

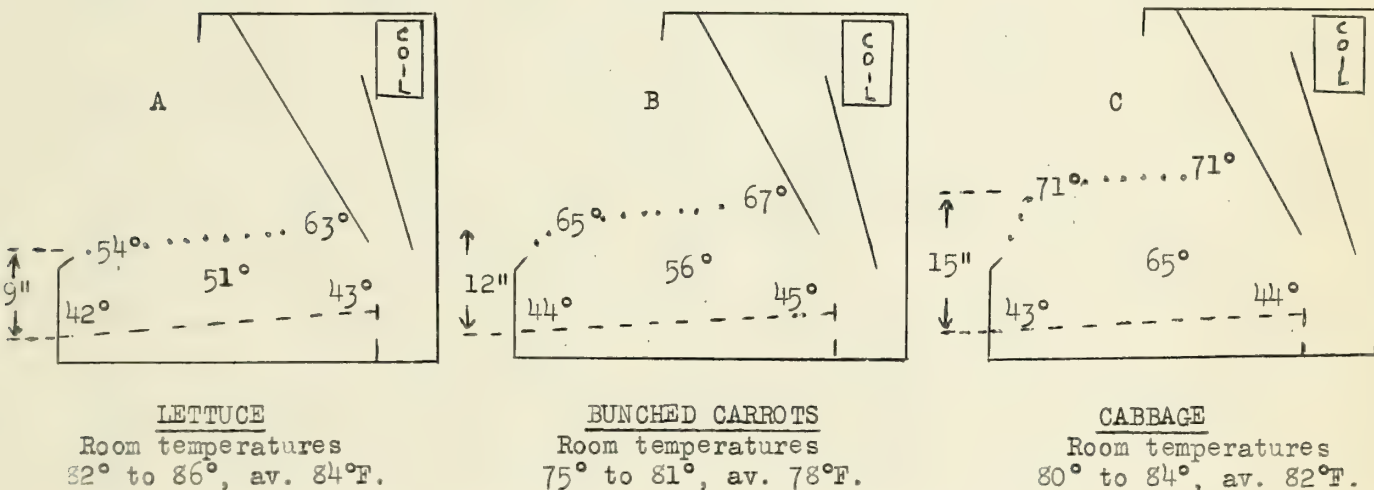


Fig. 4. Effect of Position Upon Temperatures of Produce Displayed on Regular Rack in Mechanically Refrigerated Case

Temperatures at various positions in the display case are shown in cross-section diagrams below. The temperatures are averages of 12 to 17 daytime readings at each position over a period of 4 to 5 days.

The depth of the produce on the racks is indicated at the left of each diagram.

The dotted line from the front to the back of each case indicates the top of the produce.



The produce was kept in the mechanically refrigerated case continuously; it was covered with heavy paper during the night.

Table 1. Comparison of Produce Temperatures<sup>1/</sup> on False Bottom Rack and on the Regular Rack in a Mechanically Refrigerated Display Case (Convection type)

Commodity	Test No.	Depth of Produce	Daytime Produce Temperatures-°F.				Daytime Display Room Air Temperatures	
			False Bottom Rack		Regular Rack			
			RANGE	AVE.	RANGE	AVE.	RANGE	AVE.
Beans, Snap	1	7 inches	40 - 70,	59	31 - 65,	43	68 - 78,	73
"	2	"	51 - 65,	60	35 - 47,	38	70 - 79,	74
"	3	"	47 - 72,	61	34 - 48,	40	69 - 81,	76
Averages				60		40		74
Beets, Bunched	1	4 layers	43 - 70,	56	36 - 65,	45	68 - 81,	74
"	2	"	41 - 73,	55	34 - 61,	46	66 - 81,	75
Averages				55		45		74
Broccoli	1	1 layer	51 - 63,	59	34 - 47,	40	71 - 79,	74
"	2	"	47 - 66,	59	35 - 46,	41	68 - 78,	72
Averages				59		40		73
Carrots, Bch	1	5 layers	40 - 69,	56	33 - 63,	45	66 - 76,	72
"	2	"	51 - 68,	60	36 - 50,	42	70 - 79,	76
Averages				58		43		75
Cauliflower	1	1 layer	49 - 68,	62	39 - 54,	46	70 - 79,	76
"	2	"	52 - 71,	64	43 - 51,	47	73 - 85,	80
"	3	"	57 - 68,	63	49 - 57,	53	70 - 81,	76
"	4	"	57 - 65,	62	40 - 52,	46	70 - 76,	73
"	5	"	51 - 66,	59	38 - 50,	43	66 - 74,	71
Averages				62		47		75
Cucumbers	1	6 - 8 in.	45 - 63,	55	38 - 49,	43	73 - 85,	80
"	2	"	48 - 63,	56	37 - 52,	42	67 - 78,	73
Averages				55		42		76
Lettuce, Icebg	1	2 layers	50 - 68,	61	38 - 57,	45	75 - 78,	76
"	2	"	49 - 67,	57	37 - 58,	45	72 - 75,	73
Averages				59		45		74
Onions, Green	1	6 inches	40 - 70,	58	35 - 58,	47	66 - 78,	73
Radishes, Bch.	1	2 layers	58 - 67,	60	36 - 46,	42	70 - 79,	76
"	2	"	48 - 64,	57	33 - 49,	41	69 - 79,	74
"	3	"	52 - 69,	60	37 - 55,	43	69 - 84,	79
Averages				59		42		76
Grand Averages				58		43		74

<sup>1/</sup> These figures are based upon 1740 temperature readings taken of produce displayed on the false bottom rack and an equal number of readings on the regular rack. The number of readings ranged from 52 to 316, averaging 193 for each of the commodities. Readings were taken at 2 to 5 different positions on each rack, depending upon the depth of the produce.



Temperatures of Produce in a Non-Refrigerated Case and During Overnight Storage at 40° and 50° F.

Hourly temperature changes in three different kinds of produce are shown in figures 5 to 7, inclusive. Temperature changes in other produce tested show similar curves.

A comparison of the daytime temperatures of the produce with that of the display room air temperatures shows that the cooling effect of night storage in the refrigerated rooms carried through the following day. In no case did the daytime produce temperatures reach ~~that~~ of the display room air temperature.

Rapidity of cooling and heating varied somewhat with the different types of commodities. With the more solid commodities - apples, cucumbers, and cabbage - the hourly changes in temperature were more gradual than with leafy vegetables.

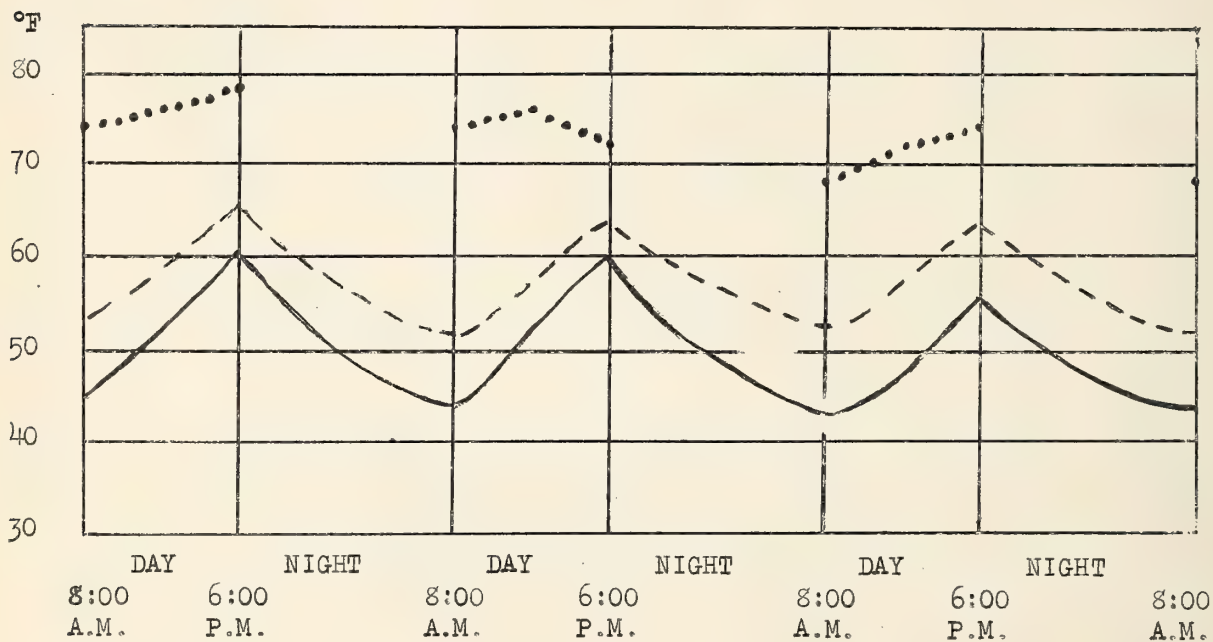
These charts are based upon temperatures obtained in approximately one-bushel lots of each of the commodities.

Fig. 5. APPLES - Temperature Changes in Produce While Displayed on Non-Refrigerated Rack During Daytime and While in Night Storage Rooms at 40° and 50°F.

--- APPLE TEMPERATURES IN 50°F. ROOM AT NIGHT AND ON NON-REFRIGERATED RACK DURING DAYTIME

— APPLE TEMPERATURES IN 40°F. ROOM AT NIGHT AND ON NON-REFRIGERATED RACK DURING DAYTIME

..... DISPLAY ROOM AIR TEMPERATURES DURING DAYTIME



FIRST 24-HOUR PERIOD SECOND 24-HOUR PERIOD THIRD 24-HOUR PERIOD



Fig. 6 KALE - Temperature Changes in Produce While Displayed on Non-Refrigerated Rack During Daytime and While in Night Storage Rooms at 40° and 50°F.

--- KALE TEMPERATURES IN 50°F. ROOM AT NIGHT AND ON NON-REFRIGERATED RACK DURING DAYTIME

\_\_\_\_\_ KALE TEMPERATURES IN 40°F. ROOM AT NIGHT AND ON NON-REFRIGERATED RACK DURING DAYTIME

..... DISPLAY ROOM AIR TEMPERATURES DURING DAYTIME

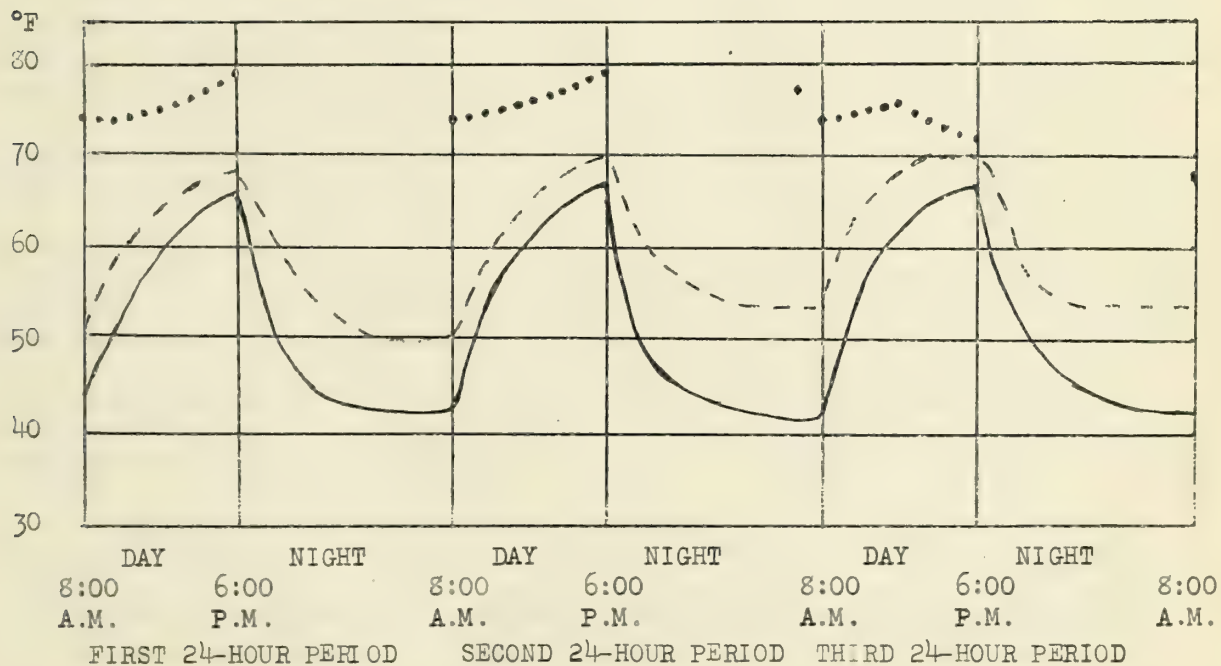
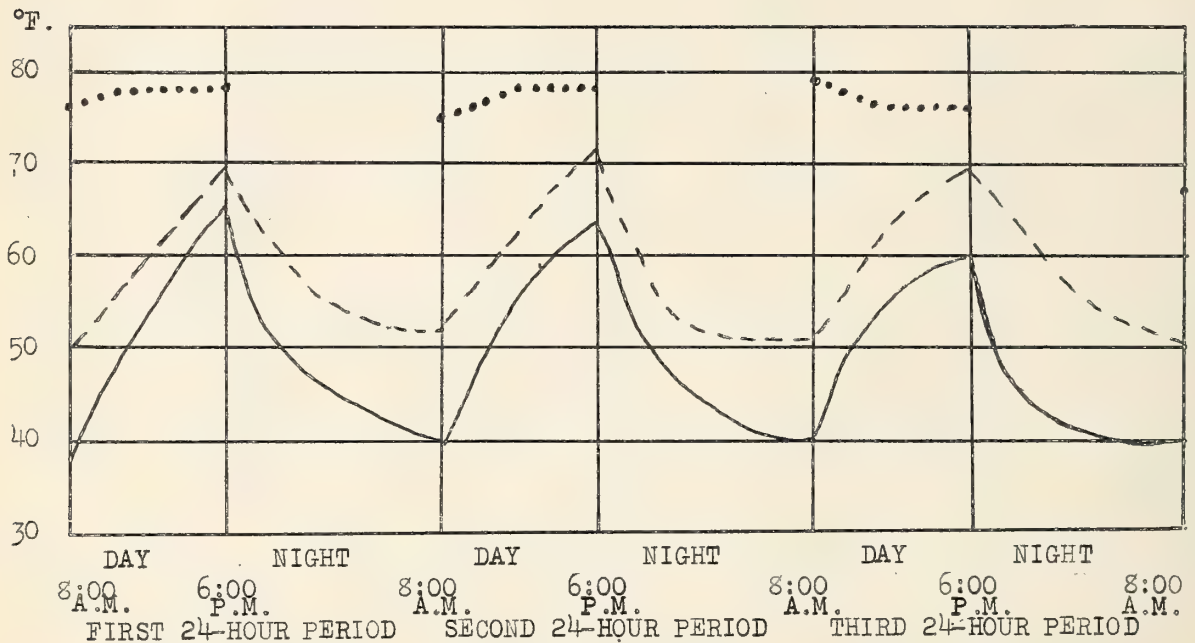


Fig. 7 CARROTS, bunched - Temperature Changes in Produce While Displayed on Non-Refrigerated Rack During Daytime and while in Night Storage Rooms at 40° and 50°F.

- - - CARROT TEMPERATURES IN 50°F. ROOM AT NIGHT AND ON NON-REFRIGERATED RACK DURING DAYTIME

—— CARROT TEMPERATURES IN 40°F. ROOM AT NIGHT AND ON NON-REFRIGERATED RACK DURING DAYTIME

..... DISPLAY ROOM AIR TEMPERATURES DURING DAYTIME





## Use of the Produce Barrel for Night Storage and Its Effect Upon Produce Temperatures

The produce barrel is used by some retail store operators to hold produce under refrigeration over night. (A sketch of a packed produce barrel is shown in figure 1, page 8.)

In packing the barrel, two or three inches of crushed ice was first spread over the slatted rack in the bottom of the barrel. The barrel was then filled with alternate layers of produce and crushed ice and a wet burlap sack was placed over the top of the barrel. The barrel was kept in the display room during the night.

The average hourly temperatures <sup>1/</sup> obtained during four tests with vegetables stored overnight in a metal produce barrel are shown in figure 8, page 20. Slight variations in the temperature curves may be due to several causes, such as the kind, condition, and volume of produce, the amount of crushed ice used, and the display room air temperatures. In these tests, the 24-hour average produce temperatures were 24 to 30 degrees below the display room air temperatures.

Both metal and wood produce barrels were used in some of the tests to determine the relative values of each. There were no differences in the produce temperatures in the two types of barrels (see fig. 9, page 21).

The effect of position in the produce barrels upon temperatures of the vegetables is shown in figure 10, page 21. Lower temperatures were found in the center of each layer than near the sides of the barrel. This fact should be given important consideration when packing vegetables that are subject to injury by temperatures below 40° F.

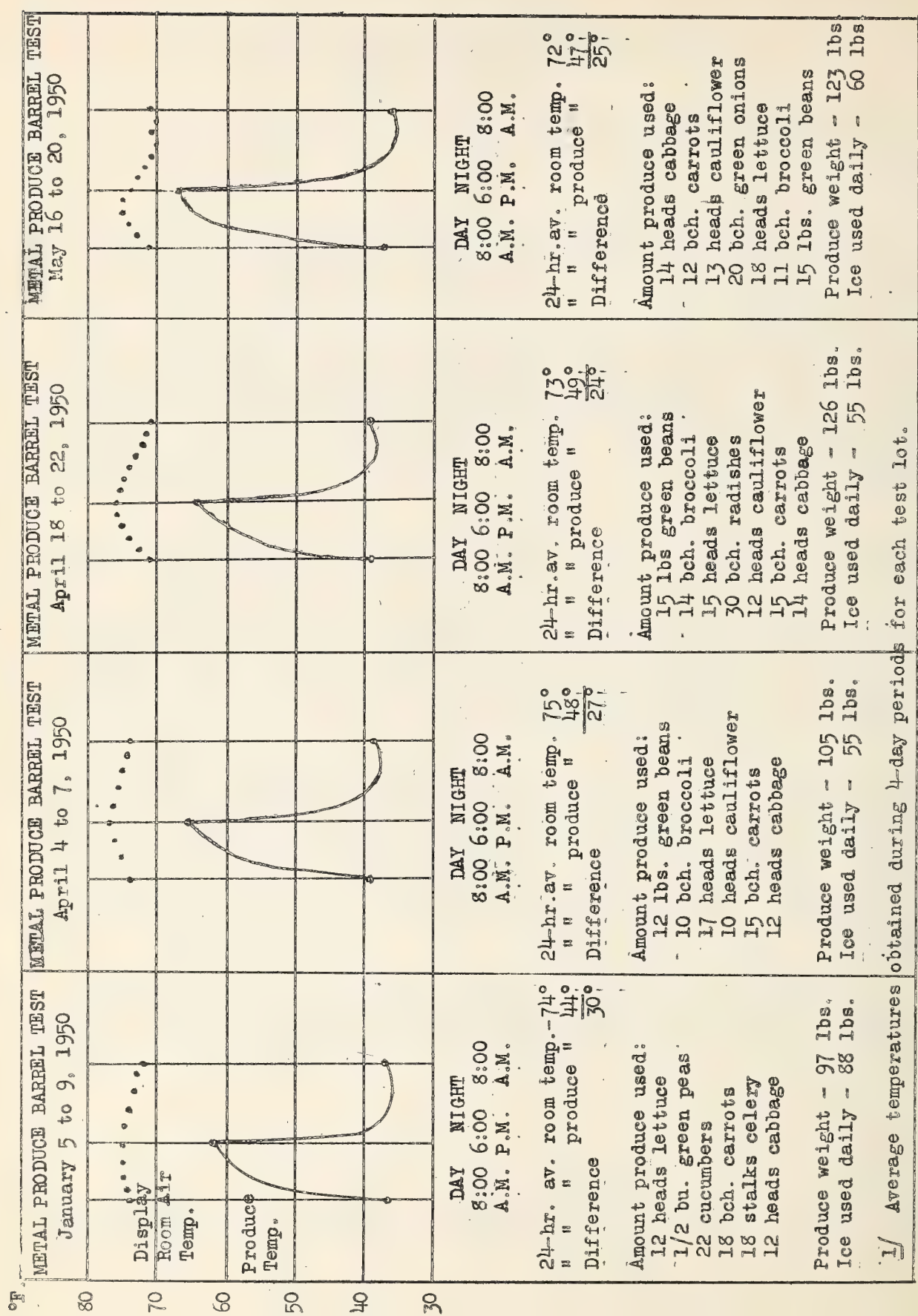
Certain vegetables heated more rapidly than others when removed from night refrigeration. The temperature of green onions, for example, rose more quickly than that of the other vegetables in this test. In most instances, such vegetables also cooled very rapidly, although their temperatures did not fall as low as the other commodities in the produce barrels. When placed in the 40° F. room, a very sharp drop in the temperature of the onions occurred within an hour, with the curves leveling off at approximately 40°. In most instances, the temperatures of lettuce in the produce barrels dropped lower than the temperatures of the other vegetables.

The temperatures of vegetables in the produce barrels began to rise slightly during the early morning hours while still in the barrels. This rise in temperature was probably due to the reduced amount of ice remaining.

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<sup>1/</sup> Temperatures were taken in the middle of the various layers of produce.

Fig. 8. TEMPERATURE 1/ CHANGES IN PRODUCE IN A NON-REFRIGERATED DISPLAY CASE DURING THE DAYTIME AND WHILE HELD IN AN ICED PRODUCE BARREL AT NIGHT



1/ Average temperatures obtained during 4-day periods for each test lot.



Fig. 9 - Temperatures of Produce Displayed in a Non-Refrigerated Case During the Daytime and While Held in a Metal and a Wood Produce Barrel and in a 40° Room at Night. (Average temperatures of seven different vegetables).

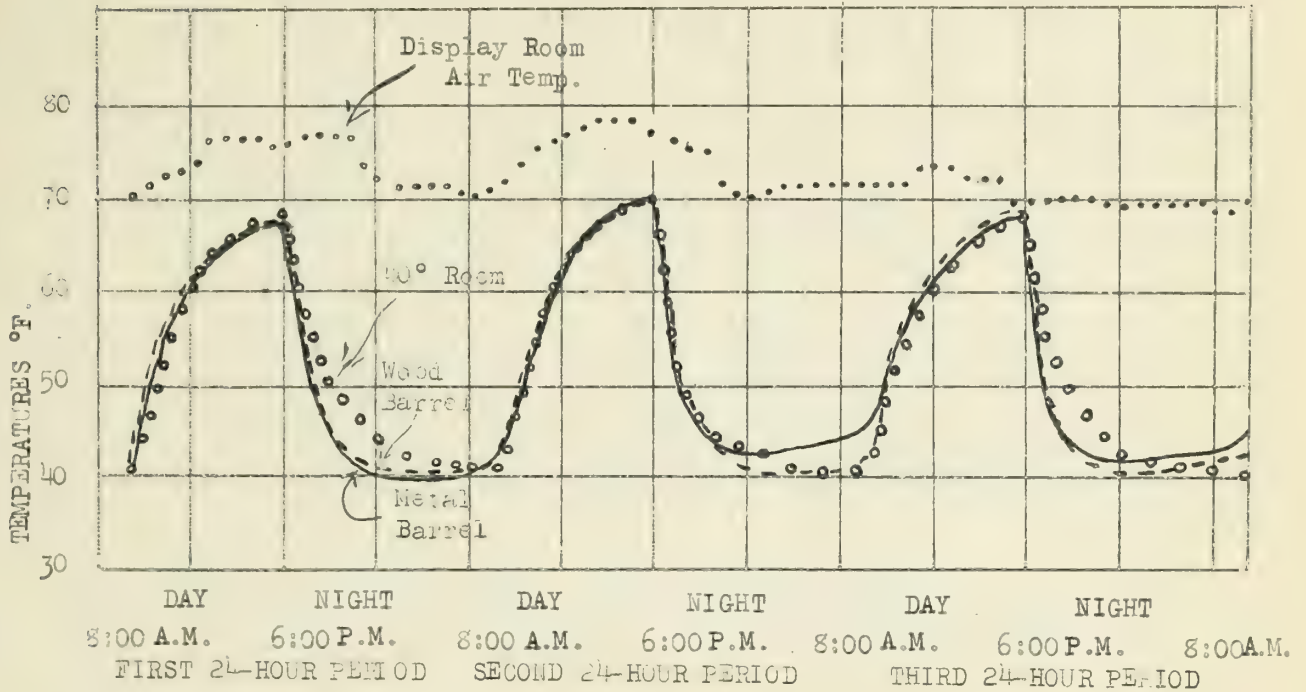
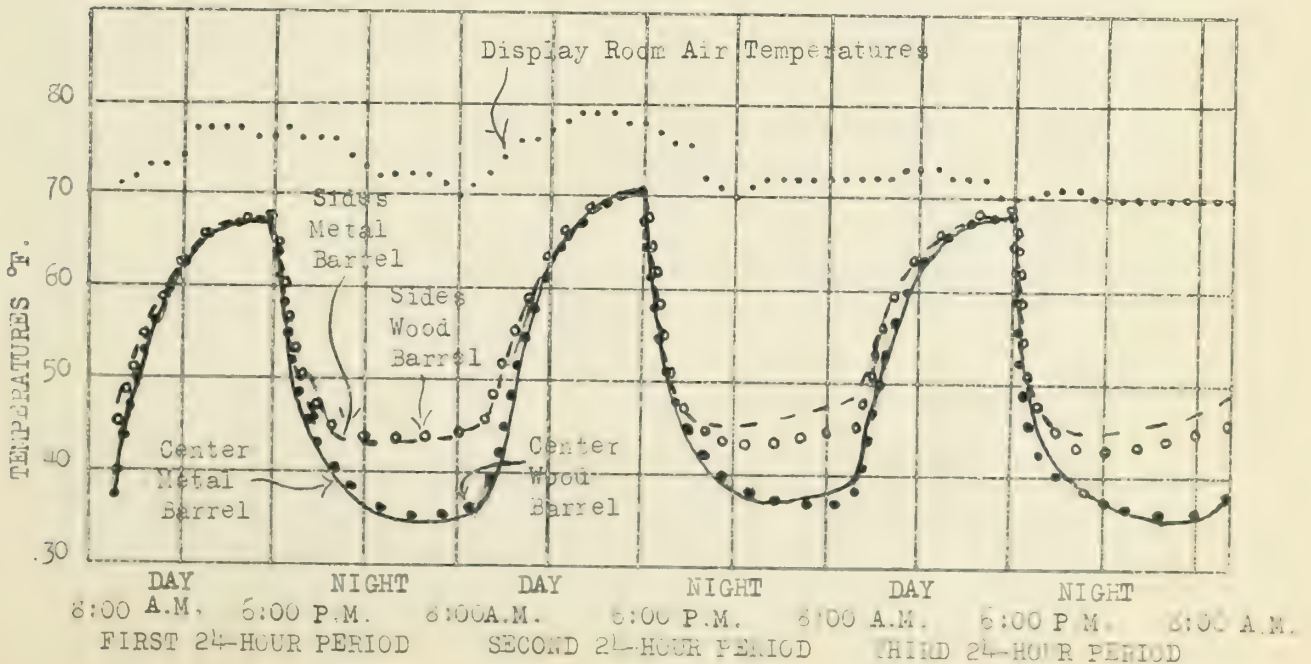


Fig. 10 - Effect of Location in Produce Barrels Upon Temperatures of Produce (Average temperatures of seven different vegetables)



Summary of Temperatures Obtained in Fifteen Different Tests of Produce Displayed in a Non-Refrigerated Case During the Daytime and Stored at Night in Iced Produce Barrels and in Walk-in Storage Rooms Held at 40° and 50°F.

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Comparisons of temperatures of produce stored at night under certain conditions are shown in table 2, page 23.

Produce held overnight in the 50° F. room had an average temperature that was 16 degrees lower than the display room temperature; that held at 40° overnight was 23 degrees cooler than the display room, and the vegetables stored overnight in the produce barrels had average temperatures 24 and 25 degrees cooler than the display room. Thus, overnight refrigerated storage gave an appreciable reduction in the 24-hour produce temperatures.

Differences between the average day and the average night temperatures of certain commodities was very small (see table 2). The average night temperature of apples in the 40° F. room was 48° and their average daytime temperature was 50°, a difference of only 2 degrees. In the 50° room the average apple temperature was 57° at night and 58° in the daytime, a difference of only 1 degree. Some leafy vegetables showed rather wide differences between the day and night temperatures.

The average daytime produce temperatures of the 15 tests shown in table 2 ranged from 50° to 64° F., mostly between 55° and 60°, while the average display room air temperatures ranged from 72° to 75°.



Table 2. Summary of Temperatures 1/ Obtained in Produce Displayed in a Non-Refrigerated Case During the Daytime and While Held in 40° and 50°F. Storage Rooms or in Iced Produce Barrels at Night.

Test No.	Night Storage Treatment	Average Amount of Ice Used Daily	Number and Weight of Commodities in Tests (2)	Daytime Display Room Air Temps.	Average Daytime Produce Temps.	Average Night Produce Temps.	Differences Between Day and Night Avg. Temps.	Average 24-hour Produce Temps.	Differences Between 24-hour Averages of Produce and Display Room Air Temps.
		Lbs.	No. & Wt.	°F.	°F.	°F.	°F.	°F.	°F.
1.	40° Room	-	1 (20 lbs)	74	58	47	11	51	23
2.	" "	-	1 (50 lbs)	74	50	48	2	49	25
3.	" "	-	3 (120 lbs)	74	52	47	5	50	24
4.	" "	-	6 (102 lbs)	75	58	46	12	50	25
5.	" "	-	7 (121 lbs)	73	58	46	12	51	22
6.	" "	-	7 (136 lbs)	72	59	46	13	51	21
7.	50° Room	-	1 (20 lbs)	74	64	57	7	60	14
8.	" "	-	1 (50 lbs)	74	58	57	1	57	15
9.	" "	-	3 (115 lbs)	75	59	56	3	57	18
10.	Metal Bbl.	88	6 (117 lbs)	74	55	38	17	44	30
11.	" "	55	6 (105 lbs)	75	57	43	14	48	27
12.	" "	55	7 (126 lbs)	73	56	43	13	49	24
13.	" "	60	7 (123 lbs)	72	60	45	15	51	21
14.	Wood Bbl.	55	7 (121 lbs)	73	55	40	15	47	26
15.	" "	60	7 (123 lbs)	72	60	45	15	51	21

1/ Temperatures are based on averages obtained during 4-day test periods. Night temperatures of produce in barrels were taken in the center of various layers with recording thermometers and thermocouples.

2/ The commodities used in the various tests were as follows:

Tests Nos. 1 & 7 - Kale.

" " 2 & 8 - Apples.

" " 3 & 9 - Cucumbers, Carrots (bunched), and Cabbage.

" " 4 & 11- Snap Beans, Lettuce, Carrots (bunched), Broccoli, Cauliflower, and Cabbage.

" " 5, 12 & 14 - Cabbage, Carrots (bunched), Cauliflower, Lettuce, Broccoli, Snap Beans, & Radishes (bunched).

" " 6, 13, & 15- Cabbage, Carrots (bunched), Cauliflower, Lettuce, Broccoli, Snap Beans, & Green Onions.

" " 10 - Carrots (bunched), Cucumbers, Lettuce, Green Peas, Celery, and Cabbage.

#### Effect of Sprinkling with Tap Water on Temperatures of Produce.

Tests were made with 10 different vegetables to determine the effect of sprinkling tap water on the temperature of produce (table 3). Temperature readings of paired lots of sprinkled and non-sprinkled produce were taken at similar positions on non-refrigerated and mechanically refrigerated display racks. The vegetables were sprinkled 4 times daily, just after the temperatures were recorded.

Results of the tests show that sprinkling with tap water four times daily had no cooling effect upon produce displayed in non-refrigerated and mechanically refrigerated display cases. The average daytime temperature of all of the non-sprinkled produce was 54.4° and the sprinkled 54.5° F.

Table 3. Effect of Sprinkling with Tap Water on Temperatures of Produce

COMMODITY	Non-Refrigerated Case During Day				In Mechanically Refrigerated Case Continuously			
	32°F. at Night		40°F. at Night		Regular Rack		False Bottom Rack	
	Not Sprin- kled	Sprin- kled	Not Sprin- kled	Sprin- kled	Not Sprin- kled	Sprin- kled	Not Sprin- kled	Sprin- kled
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Beans,	57	58	60	60	40	40	62	61
Snap	--	--	62	62	43	44	59	59
	55	55	57	57	38	39	60	60
	--	--	58	58	--	--	--	--
	--	--	54	54	--	--	--	--
Beets	54	54	57	58	45	46	55	58
bunched	56	56	59	59	46	46	55	55
Broccoli	54	55	56	57	40	40	60	59
	59	58	--	--	44	44	--	--
	--	--	58	56	49	50	--	--
	54	54	57	57	41	42	59	60
Cabbage	--	--	--	--	58	60	--	--
Carrots,	53	52	55	55	42	42	59	61
bunched	--	--	74	74	54	54	--	--
	60	60	--	--	47	48	--	--
	--	--	56	54	45	46	56	56
Cauli- flower	--	--	57	57	44	43	59	60
	--	--	57	58	46	47	62	63
	60	60	62	62	49	50	63	65
	--	--	59	58	46	46	63	62
	--	--	59	59	53	53	63	63
Cucumbers	51	50	54	54	42	43	57	56
	58	58	62	60	44	43	54	57
	--	--	70	69	51	51	--	--
Lettuce,	55	53	58	57	45	46	61	59
Iceberg	51	50	54	53	45	45	58	57
Onions, green	58	57	60	60	47	47	58	58
Radishes, bunched	--	--	63	63	49	49	--	--
	58	59	59	57	43	43	58	62
	57	57	59	59	40	42	57	57
	--	--	60	61	42	42	63	57
Averages	55.9	55.6	59.1	58.9	45.4	45.9	59.1	59.3



## Shelf Life of Produce Stored Overnight in Produce Barrels or Refrigerated Rooms and Displayed in Non-Refrigerated Case.

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The effect of the method used for overnight storage on weight loss and shelf life was determined for 8 vegetables which included snap beans, Italian sprouting broccoli, new cabbage, bunched carrots, cauliflower, Iceberg lettuce, green onions, and bunched radishes.

A description of each type of produce barrel and the method of packing the produce is given in the discussion of equipment and methods. The produce was displayed in a non-refrigerated case for approximately 10 hours during the daytime and stored for about 14 hours at night in either the produce barrels or in the 40° F. room.

A comparison of the temperatures of produce held overnight in each type of barrel, and in the 40° room is shown in figure 9. Of 14 paired treatments in each type of produce barrel (table 4), only one test showed a material difference in the shelf life of the vegetables stored at night in the two barrels. This was to be expected since temperatures were essentially the same in the wood and metal barrels. Thirteen of the 14 lots from each barrel were attractive at the end of 1 day, 9 after two days, and 4 after three days. In one lot, the broccoli in both types of barrels was attractive at the end of 1 day, but at the end of the second day, 5 out of 14 bunches in the metal barrel were unattractive whereas only one of the 14 bunches in the wooden barrel was unattractive. The difference was probably due to the broccoli and not the method of overnight storage. In one test, green beans in both produce barrels had become unattractive at the end of the third day, but the beans stored at night in the 40°F. room were still attractive.

The produce stored overnight in both barrels (table 5) showed practically the same increase in weight each day of the test. The average weight of 13 vegetables 1/ in the metal barrel had increased by approximately 3, 4, and 6 percent, respectively, at the end of the first, second, and third days of the tests, and in the wood barrel by 3, 5, and 6 percent, respectively, while the produce stored at night in the 40° room gained only 1, 1, and 2 percent respectively, due to moisture absorption from sprinkling during the display.

## Shelf Life of Produce Displayed in Ice Bed Case

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Thirty tests (tables 6 & 7), involving 76 different lots, were made in an ice bed case with the following vegetables: bunched beets, broccoli, new cabbage, bunched carrots, cauliflower, cucumbers, lettuce, and bunched radishes.

Five different methods of handling were studied. At the start of the tests, 3 to 5 inches of crushed ice was spread over the bottom of the case. The bed of ice was replenished daily. After the produce had been arranged on top of the

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1/ The weight changes in radishes were not determined because of their poor condition at the end of the second day.

Table 4. Effect of Night Storage in a Metal and a Wood Produce Barrel, and in a 40°F. Room on the Attractiveness of Produce After Daytime Display in a Non-Refrigerated Case

Commodity	NON-REFRIGERATED RACK DURING DAYTIME Produce Sprinkled 4 Times Daily								
	Metal Produce Barrel			Wood Produce Barrel			40°F. Room		
	At Night			At Night			At Night		
	Days Displayed			Days Displayed			Days Displayed		
	1	2	3	1	2	3	1	2	3
Beans, Tendergreen	A	A	A	A	A	A	A	A	A
" "	A	A	U	A	A	U	A	A	A
Broccoli	A	U	U	A	A	U	A	A	U
" "	A	U	U	A	U	U	A	U	U
Cabbage	A	A	A	A	A	A	A	A	A
" "	A	A	A	A	A	A	A	A	A
Carrots, bunched	A	A	U	A	A	U	A	A	U
" "	A	A	U	A	A	U	A	A	U
Cauliflower	A	U	U	A	U	U	A	U	U
" "	A	U	U	A	U	U	A	U	U
Lettuce, Iceberg	A	A	U	A	A	U	A	A	U
" "	A	A	A	A	A	A	A	A	A
Onions, Green	A	A	U	A	A	U	A	A	U
Radishes, Bunched	A	U	U	A	U	U	A	U	U
Total Attractive	14	9	4	14	10	4	14	10	5
Total Unattractive	0	5	10	0	4	10	0	4	9

"A" = "Attractive" -- "U" = "Unattractive"

Table 5. Effect of Night Storage in a Metal and in a Wood Produce Barrel, and in a 40°F. Room on the Weight of Produce After Daytime Display in a Non-Refrigerated Case

Commodity	NON-REFRIGERATED RACK DURING DAYTIME Produce Sprinkled 4 Times Daily								
	Metal Produce Barrel			Wood Produce Barrel			40°F. Room		
	At Night			At Night			At Night		
	Days Displayed			Days Displayed			Days Displayed		
	1 %	2 %	3 %	1 %	2 %	3 %	1 %	2 %	3 %
Beans, Tendergreen	+3	+5	+7	+2	+4	+6	+2	+2	+4
" "	+4	+7	+11	+5	+8	+11	+1	+2	+3
Broccoli	+5	+7	+8	+5	+6	+8	+4	+4	+6
" "	+4	+4	+5	+4	+5	+5	+3	+3	+3
Cabbage	+1	+1	+2	+1	+2	+2	+1	0	+1
" "	+1	+1	+2	0	+1	+1	-1	-1	-1
Carrots, Bunched	+4	+5	+5	+5	+6	+5	+3	+4	+4
" "	+4	+6	+8	+5	+9	+9	0	+2	+1
Cauliflower	+2	+3	+2	+2	+4	+3	+2	+2	+2
" "	+2	+3	+5	+2	+3	+4	0	-1	-2
Lettuce	+3	+5	+13	+3	+5	+18	+2	+2	+11
" "	+2	+3	+4	+3	+2	+4	0	0	0
Onions, Green	+2	+4	+2	+4	+6	+4	-1	-2	-5
AVERAGES	+2.8	+4.2	+5.7	+3.2	+4.7	+6.2	+1.2	+1.3	+2.1

ice bed different lots were subjected to the following treatments:

1. The produce was garnished with a thin layer of crushed ice 3 times during the daytime and once with a thick layer at night. It was not sprinkled at any time.
2. The produce was garnished only at night with a thick layer of crushed ice and was sprinkled 4 times daily.
3. The produce was garnished with ice at night as in (2) but was not sprinkled at any time.
4. The produce was not garnished at any time and was sprinkled 4 times daily.
5. The produce was not garnished or sprinkled at any time.

The vegetables were displayed for approximately 10 hours during the daytime and covered with heavy paper during the night.

When produce was handled as described under (1) (garnished several times daily) all lots were attractive at the end of the first day; of 30 lots, 97 percent were attractive after two days, and 83 percent after three days.

When vegetables were garnished with ice only at night and sprinkled several times daily, all lots remained attractive for one day; of 24 lots 96 percent were attractive after two days, and 88 percent after three days.

When the vegetables were garnished with ice only at night and not sprinkled, all lots were attractive for one day; of 22 lots, 95 percent were attractive for two days, and 86 percent after 3 days.

Only two tests were made with produce which had not been garnished with ice at any time - one with broccoli and one with bunched radishes. The sprinkled and the non-sprinkled lots of broccoli were both attractive at the end of the first day. Both lots were unattractive at the end of the second day but the non-sprinkled broccoli had deteriorated in quality to a greater extent than the sprinkled lot. The sprinkled and non-sprinkled lots of radishes were both unattractive at the end of the first day, the sprinkled lot showing greater deterioration because of slimy leaves.

No moisture losses occurred in any of the produce that had been garnished with ice several times daily and several lots of vegetables had gained appreciably in weight.

Of the produce which had been garnished only at night, all of the sprinkled lots gained in weight except cucumbers which maintained their original weight. The non-sprinkled lots showed no change or very slight loss of weight in most tests; only a few lots gained or lost appreciable weight.

Of the two tests that were made with produce which had not been garnished at any time, the non-sprinkled broccoli lost 3, 6, and 8 percent in weight after 1, 2, and 3 days, respectively, while the sprinkled lot lost 1 percent during the first day but gained 2 and 4 percent, respectively, during the second and third days. Weight changes in the bunched radishes were not obtained after the first day because of their poor condition. At the end of the first day however, the non-sprinkled radishes had lost 4 percent while the sprinkled lot had lost 2 percent in weight.



Table 6. Attractiveness of Produce as Affected by Different Handling Practices in an Ice Bed Case

Treatments and Commodities	Appearance at End of 1, 2, and 3 Days											
	1 Day				2 Days				3 Days			
	Non-Sprinkled		Sprinkled		Non-Sprinkled		Sprinkled		Non-Sprinkled		Sprinkled	
	At-tractive	Unat-tractive	At-tractive	Unat-tractive	At-tractive	Unat-tractive	At-tractive	Unat-tractive	At-tractive	Unat-tractive	At-tractive	Unat-tractive
	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests	No. of Tests
Produce Garnished 4 Times Daily												
Beans, Snap	3	0			3	0			3	0		
Beets, Bunched	2	0			2	0			2	0		
Broccoli	5	0			5	0			4	1		
Cabbage, New	1	0			1	0			1	0		
Carrots, Bunched	4	0			4	0			2	2		
Cauliflower	5	0			5	0			5	0		
Cucumbers	3	0			3	0			2	1		
Lettuce	2	0			2	0			2	0		
Onions, Green	1	0			1	0			1	0		
Radishes, Bunched	4	0			3	1			3	1		
Produce Garnished only at Night												
Beans, Snap	3	0	3	0	3	0	3	0	3	0	3	0
Beets, Bunched	2	0	2	0	2	0	2	0	2	0	2	0
Broccoli	3	0	3	0	3	0	3	0	2	1	3	1
Carrots, Bunched	2	0	3	1	1	1	2	1	1	1	2	1
Cauliflower	5	0	5	0	5	0	5	0	5	0	5	0
Cucumbers	2	0	2	0	2	0	2	0	2	0	2	0
Lettuce	2	0	2	0	2	0	2	0	2	0	2	0
Onions, Green	1	0	1	0	1	0	1	0	1	0	1	0
Radishes, Bunched	2	0	3	0	2	0	3	0	1	1	2	1
Produce Not Garnished at any Time												
Broccoli	1	0	1	0	0	1	0	1	0	1	0	1
Radishes, Bunched	0	1	0	1	0	1	0	1	0	1	0	1

Table 7. Weight Changes in Produce as Affected by Different Handling Practices in Ice Bed Case

Treatments and Commodities	No. of Tests	Not Sprinkled		Sprinkled	
		Days Displayed		Days Displayed	
		$\frac{1}{\%}$	$\frac{2}{\%}$	$\frac{1}{\%}$	$\frac{2}{\%}$
Produce Garnished 4 Times Daily					
Beans, Snap	3	+1	+4		
Beets, Bunched	2	+5	+7		
Broccoli	5	0	+1		+6
Cabbage, New	1	--	+1		+8
Carrots, Bunched	4	+1	+3		+1
Cauliflower	5	+2	+3		+1
Cucumbers	3	0	0		+5
Lettuce	2	+1	+1		+3
Onions, Green	1	+4	+6		0
Radishes, Bunched	4	+4	+6		+1
					+7
					+5
Produce Garnished Only at Night					
Beans, Snap	3	0	+1	+1	+4
Beets, Bunched	2	+1	+1	+4	+5
Broccoli	3	-1	-1	+2	+8
Carrots, Bunched	3	0	0	+2	+5
Cauliflower	5	0	-1	+2	+3
Cucumbers	2	0	0	+2	+3
Lettuce	2	0	0	0	0
Onions, Green	1	0	0	+1	+1
Radishes, Bunched	2	0	+2	+3	+7
			+2	+5	+4
Produce Not Garnished at any Time					
Broccoli	1	-3	-6	-1	+4
Radishes, Bunched	1	-4	--	-2	--

# Shelf Life of Produce Displayed in a Mechanically Refrigerated Case on the Regular Rack and on a False Bottom Rack

Twenty-two tests were made with paired treatments of produce displayed on a false bottom and on the regular rack in a mechanically refrigerated case (convection type).

The produce displayed on the regular rack remained attractive longer than that displayed on the false bottom rack (table 8).

Of 22 lots of sprinkled produce, all remained attractive on both types of racks for one day; all were attractive on the regular rack but only 77 percent of the lots on the false bottom rack were attractive by the end of the second day; and after three days, 95 percent on the regular rack but only 32 percent of the sprinkled lots on the false bottom rack were attractive. Non-sprinkled produce also showed greater deterioration when displayed on the false bottom rack than on the regular rack in the mechanically refrigerated case.

Table 8. Attractiveness of Produce Displayed on a False Bottom Rack and on the Regular Rack in a Mechanically Refrigerated Case

Commodity	Regular Rack						False Bottom Rack					
	Not Sprinkled			Sprinkled			Not Sprinkled			Sprinkled		
	Days			Days			Days			Days		
	1	2	3	1	2	3	1	2	3	1	2	3
Beans, Valentine	A	A	A	A	A	A	A	A	A	A	A	A
" "	A	A	A	A	A	A	A	A	A	A	A	A
" Wade	A	A	A	A	A	A	A	A	A	A	A	A
Beets, Bunched	A	A	A	A	A	A	A	A	U	A	A	U
" "	A	A	A	A	A	A	A	A	U	A	A	U
Broccoli	A	A	A	A	A	A	A	A	U	A	A	U
" "	A	A	A	A	A	A	A	A	U	A	A	U
Carrots, Bunched	A	U	U	A	A	A	U	U	U	A	U	U
" "	A	A	U	A	A	U	A	A	U	A	A	U
Cauliflower	A	A	A	A	A	A	A	U	U	A	U	U
" "	A	A	A	A	A	A	A	A	U	A	U	U
" "	A	A	U	A	A	A	A	A	U	A	A	U
" "	A	A	A	A	A	A	A	A	A	A	A	U
" "	A	A	A	A	A	A	A	A	A	A	A	A
Cucumbers	A	A	U	A	A	A	A	U	U	A	U	U
" "	A	A	A	A	A	A	A	A	A	A	A	A
Lettuce	A	A	A	A	A	A	A	A	A	A	A	A
" "	A	A	A	A	A	A	A	A	A	A	A	A
Onions, green	A	A	A	A	A	A	A	U	U	A	U	U
Radishes, Bunched	A	U	U	A	A	A	U	U	U	A	A	U
" "	A	A	U	A	A	A	A	A	U	A	A	U
" "	A	A	A	A	A	A	A	A	A	A	A	U
Total Attractive	22	20	16	22	22	21	20	17	9	22	17	7
Percent "	100	91	73	100	100	95	91	77	41	100	77	32

"A" equals "Attractive" "U" equals "Unattractive"



# Effects of Sprinkling and Not Sprinkling on the Shelf Life and Weight Changes of Produce in Retail Store Display Cases

The results of studies based upon paired treatments of sprinkled and non-sprinkled produce from the same lots have been summarized in tables 9 and 10. These studies cover 98 separate treatments with 10 different vegetables. This discussion is confined to produce displayed continuously in a mechanically refrigerated case and in a non-refrigerated case during the daytime and stored at night at 32°, 40°, and 50°F.

The produce was displayed for approximately 10 hours during the daytime in the non-refrigerated case and held at night in the walk-in storage rooms. The produce in the mechanically refrigerated case was displayed on a false bottom rack and on the regular rack furnished with the case. It was covered with heavy paper and left in the case at night.

In the sprinkled treatments, the produce was sprayed lightly with tap water 4 times daily.

Ninety-six percent of the sprinkled and 94 percent of the non-sprinkled lots were attractive at the end of the 1st day; 86 percent of the sprinkled and 78 percent of the non-sprinkled lots were attractive after 2 days; and 58 percent of the sprinkled and 48 percent of the non-sprinkled lots were attractive at the end of the third day.

Table 9. Attractiveness of Produce <sup>1/</sup> as Affected by Sprinkling and Not Sprinkling in Retail Store Display Cases.

Treatments	Number of lots Attractive at End of 1, 2, and 3 Days						
	Total tests of each treatment	1st Day		2nd Day		3rd Day	
		Non-Sprin-kled	Sprin-kled	Non-Sprin-kled	Sprin-kled	Non-Sprin-kled	Sprin-kled
Non-refrigerated rack during daytime							
32°F. room at night	17	17	17	13	16	8	11
40° " " "	29	26	28	24	24	12	16
50° " " "	1	1	1	1	1	1	1
Mechanically refrigerated case							
On regular rack	29	28	28	22	27	17	22
On false bottom	22	20	20	16	16	9	7
Totals	98	92	94	76	84	47	57
Percent Attractive		94	96	78	86	48	58

<sup>1/</sup> Snap Beans, bunched beets, broccoli, cabbage, bunched carrots, cauliflower, cucumbers, lettuce, green onions and bunched radishes.

Considerable differences in weight were found between the sprinkled and the non-sprinkled produce. The sprinkled produce in the 94 paired treatments summarized in table 10 showed one percent moisture gain during the 3-day test periods. The non-sprinkled produce lost from 2.6 to 3.5 percent in 1 day, from 4.5 to 6.5 percent in 2 days, and from 6.4 to 9.2 percent in 3 days.

The moisture changes reported for each day were based upon the original weights of the produce at the start of the tests.

Table 10. Moisture Changes in Produce 1/ as Affected by Sprinkling and Not Sprinkling in Retail Store Display Cases

Treatments	Moisture Changes at End of 1st, 2nd, and 3rd Days						
	Total	1st Day		2nd Day		3rd Day	
	lots						
	in each treat- ment	Non- Sprin- kled	Sprin- kled	Non- Sprin- kled	Sprin- kled	Non- Sprin- kled	Sprin- kled
	No.	%	%	%	%	%	%
Non-refrigerated							
case during daytime							
32° room at night	17	-2.6	+0.5	-5.5	+1.4	-7.9	+1.4
40° " " "	27	-2.8	+0.3	-5.6	+1.1	-8.4	+1.9
Mechanically refrigerated case							
On regular rack	28	-2.6	+0.3	-4.5	+0.6	-6.4	+0.9
On false bottom	22	-3.5	+0.4	-6.5	+0.2	-9.2	-0.2
Total test and avgs.	94	-2.9	+0.4	-5.5	+0.8	-8.0	+1.0

1/ Snap beans, bunched beets, broccoli, cabbage, bunched carrots, cauliflower, cucumbers, lettuce, green onions and bunched radishes.

#### Detailed Studies of Individual Vegetables

##### Beans, Snap

Three lots of Black Valentine, 2 lots of Tendergreen, and 1 lot of the Wade variety of snap beans were used in these tests. The beans were displayed continuously for several days in a mechanically refrigerated and in an ice bed case. They were also displayed on a non-refrigerated rack during the daytime and stored at night in iced produce barrels and in walk-in "coolers" held at 32°, and 40°F. and high humidity. Duplicate lots on each rack were sprinkled or garnished with crushed ice several times daily. The beans were arranged in each lot 7 inches

deep, extending from the front to the back of the cases. The average display room air temperatures during each of the six 3-day testing periods were 73°, 73°, 74°, 74°, 75°, and 76°F.

The highest average daytime produce temperatures, 55° to 60°F. occurred in the beans displayed in the non-refrigerated case and on the false bottom rack in the mechanically refrigerated case.

The beans remained in good condition and were attractive for 2 days under all of the various handling practices. After 3 days only one lot was unattractive although some beans were drying and slightly flabby in several other lots under various handling practices.

Russetting of the pods developed in only one lot of beans during the testing periods in which 6 different lots were tested under various conditions of moisture and temperature. The other lots of beans, displayed and stored under similar conditions, failed to show any russetting. The previous history of the beans before being placed in the display cases may have had an important bearing upon the development of russetting.

The natural color of the beans remained generally good throughout the various tests. The most important changes in the beans under the various handling practices were losses or gains in weight due to the evaporation or absorption of moisture. Decay was of no importance under any of the various methods of handling during the 3-day tests. Only an occasional bean was affected with decay.

Beans that were not wet lost 3, 5, and 8 percent in weight, respectively, by the end of the first, second, and third days of the tests. Beans that had been garnished or sprinkled daily in the ice bed case gained 6 percent, and those stored at night in the iced produce barrel had gained 8 percent by the end of the third day. Sprinkled beans in the non-refrigerated and in the mechanically refrigerated cases gained 2 percent in weight.

Beans whose average temperatures in these tests ranged from 38° to 60° F. remained in good condition and were attractive at the end of the 3-day tests. In the non-sprinkled lots, moisture losses not only reduced the weight but also resulted in lowered quality, as evidenced by the drying of the pods after exposure on the display racks for three days. Although the non-sprinkled beans had an attractive appearance at the end of the third day and were generally crisp, some were slightly flabby. Excessive moisture losses had caused some drying of the pods that was not apparent upon casual observation.

#### Suggestions for Retail Store Operators

Snap beans having average temperatures as high as 60°F. remained in good condition for three days. When displayed on non-refrigerated racks during the daytime, snap beans should be stored at night at 40° to 50° F. When beans are given such night care or are held in mechanically refrigerated cases, sprinkling prolongs their shelf life by preventing moisture losses that cause drying and flabbiness of the pods.



### Beets, Bunched

Bunched beets from North and South Carolina and from nearby Maryland were used in these tests. The Carolina beets were obtained in original containers from the Washington, D.C., wholesale produce market and the Maryland beets were hauled directly from the field to a cold storage room at the U. S. Bureau of Plant Industry Station, Beltsville, Maryland.

They were displayed for several days in mechanically refrigerated and ice bed cases continuously and on a non-refrigerated rack during the daytime and stored at night in iced produce barrels and in walk-in "coolers" held at 32° and 40°F. and high humidity. Duplicate lots on each rack were sprinkled or garnished 4 times daily. The bunches of beets were arranged in each of the display cases 3 layers deep and extended from the front to the back.

The important defects that developed in the bunched beets were spongy roots and wilted, yellow, and decayed leaves. The beets under all methods of handling remained attractive for 2 days although slight wilting of the leaves had begun during the first day. Wilting of the leaves and sponginess of the roots, especially in the upper layers progressed each day in the non-sprinkled lots, whereas the sprinkled beets remained turgid during the 3-day tests.

The non-sprinkled beets lost 1 to 4 percent in weight because of moisture evaporation during the first day, up to 7 percent through the second day, and as much as 10 percent by the end of the third day. The greatest moisture losses occurred in the non-sprinkled beets on the false bottom rack in the mechanically refrigerated case. The sprinkled or ice garnished beets on the various racks showed material gains in weight at the end of each day of the tests.

A few slimy and slightly yellow leaves were found in the beets that had been displayed on the false bottom rack in the mechanically refrigerated case and in the sprinkled beets on the non-refrigerated rack. The daytime temperatures of the beets on these racks ranged from 54° to 59°F. Practically no yellowing or decay developed in the beets on the regular rack in the mechanically refrigerated case or in the ice bed case. The daytime beet temperatures on these racks averaged less than 50°F.

A few watersoaked leaves were present in the sprinkled lots on the non-refrigerated rack at the end of the third day.

The sprinkled beets in each of the display cases and the beets under all of the handling methods in the ice bed case remained crisp, green, practically free from decay, and were attractive at the end of the third day, whereas the beets that had not been sprinkled or wet by garnished ice had become wilted, spongy, and unattractive.

### Suggestions for Retail Store Operators

Bunched beets should be kept as cool as possible during both day and night unless they are moved rapidly into consuming channels. Temperatures as low as 32°F. will not injure bunched beets and will prolong their shelf life. Beets that have been displayed during the daytime on non-refrigerated racks should be stored under refrigeration at night.

Both tops and roots of bunched beets should be lightly sprinkled with water several times daily to prevent wilting of the leaves and sponginess of the roots. Heavy sprinkling of the closely matted leaves should be avoided. Too much water,

especially when the temperatures are high, provides ideal conditions for the development of decay. The beets in the upper layers are usually the first to become wilted and spongy, while those in the lower layers remain crisp and firm. It is desirable to apply only enough water to keep the beets moist in the upper layers.

### Broccoli, Italian Sprouting

Eight different lots of Italian sprouting broccoli from California, Texas, and Pennsylvania were obtained in original containers from the Washington, D.C. wholesale produce market. This broccoli was studied under several different methods of handling that, so far as possible, simulated certain retail store practices.

The broccoli was displayed for several days in mechanically refrigerated and ice bed cases continuously and on a non-refrigerated rack during the daytime and stored at night in iced produce barrels and in walkin "coolers" held at 32° and 40°F. and high humidity. Duplicate lots on racks were sprinkled or garnished 4 times daily. The broccoli was arranged in each case with the butts down, 1 layer deep, and extending from the front to the back of the rack.

Variable conditions of the broccoli when received from the wholesale produce market caused some irregularities in the results obtained during the tests of different handling practices. Some lots of broccoli remained attractive after 3 days in the display cases whereas other lots were unattractive after 2 days under similar conditions of moisture and temperature.

The average display room air temperatures during each of the 3-day testing periods were 72°, 73°, 74°, 74°, 75°, 75°, 76°, and 79°F.

The principal defects of a progressive nature that developed in the broccoli while displayed in 3 retail store type of cases were wilting of the leaves and wilting and yellowing of the buds. The leaves retained their characteristic green color under all of the handling methods. Decay was of importance in a few lots of sprinkled broccoli on the non-refrigerated rack in which the average daily temperature of the broccoli was above 55°F. This high produce temperature together with high humidity provided ideal conditions for the development of decay with consequent off odors.

Of 44 separate lots of broccoli, all were still attractive under each of the handling practices at the end of the 1st day; 10 were unattractive at the end of the 2nd day, and 22 were unattractive after 3 days. During the second day, unattractive displays of broccoli were found under all handling methods except the sprinkled lots on the regular rack in the mechanically refrigerated case and the garnished broccoli in the ice bed case. After 3 days, some unattractive lots of broccoli were found under all handling practices.

Yellow or bronzed buds occurred under all methods of handling, including both sprinkled and non-sprinkled broccoli. The broccoli that had been garnished with crushed ice in the ice bed case showed the least discoloration of the buds.

The broccoli that had not been sprinkled or wet at any time showed wilting in varying degrees. The wilting occurred in the leaves first, then in the buds. The greatest amount of wilting occurred in the non-sprinkled broccoli on the false bottom rack in the mechanically refrigerated case.

Sprinkled or garnished broccoli remained turgid throughout the 3-day tests in the various display cases.

The greatest weight losses, due to moisture evaporation, occurred in the broccoli that had not been sprinkled or garnished at any time. Broccoli that had been stored at night in the iced produce barrel gained the most weight during each day of the tests, and that which had been garnished several times daily in the ice bed case had the second highest gain in weight.

#### Suggestions for Retail Store Operators

Italian sprouting broccoli should be sprinkled or garnished several times daily to prevent wilting and material weight losses due to moisture evaporation. Light sprinkling is more desirable than a heavy wetting, especially at high temperatures when excessively wet produce is more likely to develop decay.

Low temperatures with high humidity gave best results in keeping the broccoli fresh, turgid, and attractive. Low temperatures were the most desirable, and temperatures as low as 32°F. do not injure broccoli.

Broccoli that has been displayed on a non-refrigerated rack during the daytime should be held at night in an iced produce barrel or in a 32° or a 40°F. refrigerated storage room. Night refrigeration results in lower daytime produce temperatures.

Broccoli displayed on a false bottom rack deteriorates much more quickly than that displayed on the regular rack in a mechanically refrigerated case.

When displayed in an ice bed case, the broccoli should be garnished with crushed ice or sprinkled several times daily to prolong the shelf life.

#### Carrots, Bunched

Seven different lots of bunched carrots from California and Texas were used in a study of the effect of various handling practices on their shelf life. All of the carrots were obtained in original containers from the Washington, D.C. wholesale produce market.

Variable conditions of the carrots when received from the wholesale produce market caused some irregularities in the results obtained during the tests of different handling methods. Some carrots remained in good condition longer than others that had been held under similar conditions of temperature and moisture. The quality of the different lots of carrots varied widely. Some lots were found to be very attractive when removed from the original containers, while other lots were very unattractive due to the presence of yellow and discolored leaves or shriveled roots. Considerable trimming of the defective parts was necessary and some bunches of carrots were discarded entirely from these lots.



After trimming and sorting into representative lots, the carrots were arranged in a non-refrigerated and a mechanically refrigerated case and in an ice bed case. In each display case duplicate lots were non-sprinkled and sprinkled or garnished with crushed ice four times daily. Bunched carrots that had been displayed during the daytime in the non-refrigerated case were held overnight in iced produce barrels and in walk-in "coolers" held at 32° and 40°F. and high humidity.

The average display room air temperatures during each of the 3-day testing periods were 72°, 73°, 74°, 75°, 75°, 79° and 90°F.

The principal defects that developed under the various handling practices were flabbiness, shriveling, and discoloration of the roots and "root-tails", and yellow and discolored leaves. Decay was of no importance except in one lot of sprinkled carrots that had been displayed in the non-refrigerated case and stored at night in the 40°F. room. In this lot, most root-tails had become slimy and discolored during the 2nd day, and at the end of the third day all of these "tails" were discolored and slimy. The average daytime display room air temperature during this 3-day test was 90° and the average daytime carrot temperature was 74°. Moisture from sprinkling several times at these high temperatures provided ideal conditions for the development of the slimy decay. Only an occasional slimy root-tail was found under the other handling practices in this test or in other 3-day tests of bunched carrots.

The color of the leaves was generally good during the first day under all handling practices, but some yellow and discolored leaves were present at the end of the second day. Yellowing and discoloration of the leaves was very irregular after 3 days, with some lots showing many such leaves while other lots were still in good condition under similar handling conditions.

Most wilted leaves and flabby, shriveled, and discolored roots were found in the non-sprinkled carrots on all display racks. The percentage of such defects was especially high in the carrots that had been displayed on the false bottom rack in the mechanically refrigerated case. No wilted leaves or flabby, shriveled, or discolored roots were present at the end of the third day in carrots that had been stored at night in the produce barrel. No wilted leaves but a few flabby, shriveled, and discolored roots were found in practically all other sprinkled lots, especially in the upper layers of bunches where the roots were exposed to the display room air temperatures.

Although low temperatures and sprinkling of the carrots are both highly desirable, sprinkling was of benefit even at ordinary display room air temperatures. Some sprinkled carrots whose temperatures were as high as 63°F. had remained attractive for 2 days, whereas some lots of non-sprinkled carrots in which the temperatures were as low as 45° had become unattractive. Sprinkled carrots whose temperatures were 55° or lower were in the best condition after 3 days in the display cases.

#### Suggestions for Retail Store Operators

Bunched carrots should be sold not later than the second day on the display racks, preferably during the first day. Yellow or discolored leaves, or flabby and shriveled roots can be expected on the third day except, possibly, under ideal conditions of temperature and moisture.

The leaves of non-sprinkled carrots wilt rapidly and the roots soon become flabby and shriveled, especially in the upper layers of bunches. Sprinkling prolongs the shelf life of carrots by preserving a fresh appearance of the leaves and firmness of the roots. Light sprinkling gave better results than heavy wetting of the bunches. Only enough sprinkling should be done to prevent drying of the tops and roots in the upper layers.

Bunched carrots that have been displayed on a false bottom rack will deteriorate more rapidly than when placed on the regular rack in a mechanically refrigerated case.

Bunched carrots that have been displayed in a non-refrigerated case during the daytime should be well refrigerated at night. Night storage in iced produce barrels or in 32° to 40°F. walk-in "coolers" will result in lower carrot temperatures during most of the following day.

When displayed in an ice bed case, garnishing or lightly sprinkling the carrots several times daily prolongs their shelf life.

### Cauliflower

Eight different lots of cauliflower were tested under various methods of handling during 1950 and 1951. The cauliflower used in these tests was grown in California, Arizona, and Long Island, New York.

It was displayed for several days in mechanically refrigerated and ice bed cases. It was also displayed on a non-refrigerated rack during the daytime and stored at night in iced produce barrels and in walk-in "coolers" held at 32° and 40°F. and high humidity. Duplicate lots on each rack were sprinkled or garnished 4 times daily. The cauliflower was arranged in each case with the butts down, 1 layer deep, and extending from the front to the back of the rack.

Variations which occurred in the different tests were probably due to the previous history of the cauliflower before it had been obtained from the wholesale produce market. At the end of the first day in the display cases, the cauliflower in all tests was attractive, regardless of the type of display case or the kind of day and night treatment. At the end of the second and third days there was considerable irregularity in the attractiveness of the cauliflower that had been treated in a similar manner during different testing periods. In some tests the cauliflower remained attractive throughout the test period, whereas in other tests it became unattractive at the end of the second day in each of the display cases.

The principal defects that developed in the cauliflower under the various handling practices were spotted discoloration and flabby condition of the curds, and wilting and some yellowing of the leaves.

The average display room air temperatures during the different tests were 71°, 73°, 74°, 75°, 76°, 76°, 76° and 80°F. In the 3-day test period, during which the average room temperature was 80°, the average produce temperatures under the various handling practices were a few degrees higher than when the display room air temperatures were lower. However, the cauliflower under all methods



of handling during this test was still attractive at the end of the second day.

More spotting occurred in the sprinkled lots of cauliflower than in the non-sprinkled, especially at the higher temperature on some of the display racks. During the second day increased spotting of the curds occurred in the cauliflower in which the daytime produce temperatures were above 50°F. This spotting was most prevalent in the sprinkled lots that had been displayed in the non-refrigerated case and on the false bottom rack in the mechanically refrigerated case. Only very slight spotting had occurred in the cauliflower displayed on the regular rack in the mechanically refrigerated case or in the lots in the ice bed case where daytime temperatures were 55° or lower.

Consistently more wilting of the leaves, flabbiness of the curds, and greater weight losses occurred in the cauliflower that had not been sprinkled than in the sprinkled or garnished lots. Wilting of both leaves and curds increased daily in the non-sprinkled cauliflower until at the end of the third day, both leaves and curds in practically all non-sprinkled lots were slightly to materially wilted. The sprinkled lots in all display cases and the ice-garnished lots in the ice bed case were generally crisp and firm throughout the 3-day tests.

No decay was present in any lot at the end of the third day and yellowing of the leaves was of little importance.

Sprinkled cauliflower that had been stored at night in the produce barrel and that which had been garnished or sprinkled in the ice bed case gained appreciably in weight during the second and third days but little change in weight occurred in the other sprinkled lots. The non-sprinkled lots had decreased 2 to 5 percent, 3 to 8 percent, and 5 to 11 percent, respectively in weight at the end of the first, second, and third days due to moisture losses.

#### Suggestions for Retail Store Operators

Sprinkling or garnishing will reduce weight losses from moisture evaporation and will lessen, if not entirely prevent, wilting of the leaves and flabbiness of the curds. However, when the average temperature of the cauliflower is above 50°F. sprinkling has a tendency to cause spotting of the curds.

Cauliflower should be kept as cool as possible -- temperatures as low as 32°F. will not injure cauliflower but will prolong its shelf life.

Cauliflower that has been displayed on non-refrigerated racks during the daytime should be stored at night in an iced produce barrel or in a refrigerated storage room.

Low temperatures and high humidity slow down the aging process of cauliflower.



## Cucumbers

Cucumbers used in these tests were obtained in original containers from the Washington, D. C. wholesale produce market. They were grown in Florida and in New York.

The cucumbers were arranged in a non-refrigerated case, a mechanically refrigerated case and in an ice bed case. In each display case duplicate lots were non-sprinkled and sprinkled or garnished with crushed ice four times daily. Cucumbers that had been displayed during the daytime in the non-refrigerated case were held overnight in iced produce barrels and in walk-in "coolers" with temperatures of 32° and 40°F. and high humidity. The cucumbers were 6 to 8 inches deep and extended from the front to the back of the racks.

In addition to the above described handling practices in the display cases, duplicate lots of cucumbers were stored in rooms held at 33°, 36°, 40°, and 50°F. to determine the effect of low storage temperatures upon the keeping quality when subsequently exposed to display room air temperatures.

Shriveled and soft ends were the principal defects found in the cucumbers that had been displayed under varying conditions in different types of retail store produce cases. These defects developed under all handling practices. Some yellowing occurred in both sprinkled and non-sprinkled cucumbers in one lot that had showed signs of aging when obtained from the wholesaler. No yellowing occurred in any other lot during the 3-day tests. Practically no decay developed under any of the various methods of handling.

In most lots there were no material differences in the weights of the sprinkled and the non-sprinkled cucumbers. In one lot that was in only fair condition when obtained at the wholesale produce market, the non-sprinkled cucumbers lost 2 to 3 percent more in weight than the sprinkled lot. In all other lots, no appreciable changes in weight occurred under any of the different handling practices, the cucumbers usually maintaining their original weight or losing not more than 1 percent because of moisture changes.

Studies of cucumbers stored continuously for 6 days in walk-in "coolers" held at 33°, 36°, 40°, and 50°F. and high humidity showed that more rapid deterioration occurred at storage temperatures of 40° and lower than at 50°. This deterioration was principally due to the development of numerous pitted areas which were followed by decay when the cucumbers were exposed to room temperatures for 1 or 2 days. No pitting was present on cucumbers that had been stored for 3 weeks at 50°, although yellowing and decay had developed during this excessively long storage period. The percentage of salable cucumbers was greater in the cucumbers stored at 50° than in the lots stored at lower temperatures.

### Suggestions for Retail Store Operators

Cucumbers may be displayed satisfactorily for a few days under any of the various handling practices. However, they will retain better quality for a longer period of time at temperatures of about 50°F. than at lower temperatures. Cucumbers that have been subjected to low temperatures for several days are

likely to become decayed soon after exposure to room temperatures. However, cucumbers will not be injured when held for a short time at temperatures as low as 35°F.

No appreciable differences were found in the shelf life of sprinkled cucumbers and those that had not been sprinkled.

### Lettuce, Iceberg Type

The five different lots of lettuce that were used in these tests were obtained in original containers from the Washington, D.C. wholesale produce market. The lettuce was grown in California.

It was tested for several days under varying conditions. Non-refrigerated, mechanically refrigerated, and ice bed cases were operated to simulate certain retail store conditions. Duplicate lots of lettuce were sprinkled or garnished with crushed ice several times daily, or not sprinkled at any time. Some lots that had been displayed during the daytime in the non-refrigerated case were held at night in a produce barrel, and in 32° and 40°F. storage rooms.

The average daytime display room air temperatures during each of the 3-day tests were 73°, 74°, 74°, 75°, and 76°F.

Loss of quality, size, and weight of the lettuce was caused principally by loose leaves that became detached in ordinary handling and by withered leaves which resulted from excessive moisture evaporation.

After one day, there were only small differences in the net weights of lettuce displayed under the various handling methods. The non-sprinkled or dry lettuce lost 2 percent but no appreciable change in weight occurred with any of the other treatments.

The greatest total weight losses during the 3-day tests occurred in the lettuce that had not been sprinkled. These losses were due to withered leaves and weight decreases caused by moisture evaporation.

The largest amount of withering occurred in the non-sprinkled lettuce in all display cases, and the least amount was found in the lettuce that had been stored in the produce barrel at night.

The greatest loose leaf loss was found in the lettuce that had been held at night in the produce barrel, and the least amount of loose leaves was in the non-sprinkled lettuce in all display cases.

Eight percent of slimy decay had developed by the third day in one lot of sprinkled lettuce that had been displayed on the false bottom rack but decay was not an important factor in any other lot.

Lettuce under all handling practices remained attractive for 1 day without reconditioning. After the second and third days, trimming of damaged leaves was necessary to improve the appearance of the lettuce in most lots.

### Suggestions for Retail Store Operators

Lettuce displayed in a mechanically refrigerated case or on a non-refrigerated rack should be lightly sprinkled several times daily. When displayed in an ice bed case it should be garnished with crushed ice daily or sprinkled several times during the daytime and garnished with a heavy layer of crushed ice when prepared for night storage.

Lettuce that has been displayed during the daytime in non-refrigerated cases should be refrigerated at night. Lettuce will retain its most desirable qualities at low temperatures and high humidity. Temperatures as low as 32°F. will not injure lettuce and will be beneficial.

### Onions, Green (bunched)

Two separate lots of bunched green onions were used in the tests. They were obtained in original containers from the Washington, D. C. wholesale produce market.

The onions were fresh, green, turgid, free from decay, and attractive when placed on the display racks where they were subjected to various handling practices. Non-refrigerated, mechanically refrigerated and ice bed cases were operated to simulate certain retail store conditions. Duplicate lots of onions were sprinkled or garnished with crushed ice several times daily or not sprinkled at any time. Some lots were garnished only when the produce was prepared for night storage. Duplicate lots that had been displayed during the daytime in the non-refrigerated case were held at night in a produce barrel and in 32° and 40°F. storage rooms.

The average daytime display room air temperatures during each of the 3-day test periods were 73° and 75°F.

The onions under all handling methods remained turgid, free from decay, and attractive at the end of the 1st day, although a few slightly yellowed leaves were present in practically all lots. The non-sprinkled onions had lost some moisture but the onions that had been garnished or sprinkled several times daily had gained in weight.

Yellowing of the leaves was the predominant defect that caused the onions to be unattractive, although slimy leaf tips, and dry and slightly brownish roots were present in some lots. Most yellowing of the leaves occurred at the higher temperatures and some was found in all except two lots at the end of the second day of the test.

After 2 days both sprinkled and non-sprinkled onions on the false bottom rack and those which were displayed on the non-refrigerated rack during the daytime and held overnight in the 40°F. room, had become unattractive because of many yellow leaves. The average daytime temperatures of each of these lots were 58° to 60°F.

After 3 days, all lots were unattractive except those on the regular rack in the mechanically refrigerated case and those in the ice bed case.



The roots of non-sprinkled onions were drying and had become slightly brown at the end of the third day, whereas the roots of the sprinkled onions still had a fresh appearance.

Onions whose average daytime temperatures were approximately 40° to 50°F. remained attractive for 3 days while those averaging 55° to 65° had become unattractive because of yellow leaves.

At the higher temperatures, the sprinkled onions showed somewhat more decay than those that had not been sprinkled. Practically no decay was found in any of the non-sprinkled lots or in the 3 lots in the ice bed case.

The onions that had been displayed on the false bottom rack in the mechanically refrigerated case deteriorated more quickly than those with any of the other methods of handling, and, at the end of the second day, they had become unattractive because of yellow leaves.

High temperatures accelerated and low temperatures retarded the development of yellow and decayed leaves.

#### Suggestions for Retail Store Operators

Green onions should be kept as cool as possible both day and night. Low temperatures are more important than sprinkling, but both are desirable. Onions may be held as low as 32°F. without injury.

Onions that have been displayed during the daytime on non-refrigerated racks should be stored at night in a produce barrel or in rooms held at temperatures below 40°F.

Green onions are subject to rapid deterioration due to heating and therefore, should be moved through retail channels as quickly as possible.

At high temperatures on display racks, sprinkling should be held to a minimum, possibly discontinued entirely. Slimy decay which might be increased by sprinkling at high temperatures would be more objectionable than loss of moisture.

Green onions should not be displayed on false bottom racks in mechanically refrigerated cases unless they can be moved into consumption during the first day on the racks.

Reserve supplies of green onions should be kept well refrigerated. Crushed ice will supply desirable temperatures and humidity. When stored in low temperature rooms, sprinkling with water would be beneficial.

#### Radishes, Bunched

Five separate and distinct lots of bunched radishes were obtained in original containers from the Washington, D. C. wholesale produce market. The various lots were stated to have been grown in Florida, South Carolina, Pennsylvania, and Ohio.

This report covers studies made with bunched radishes tested for several days under varying conditions. Non-refrigerated, mechanically refrigerated, and ice bed cases were operated to simulate certain retail store conditions. Duplicate lots of radishes were sprinkled or garnished with crushed ice several times daily,



or not sprinkled at any time. Some lots were garnished only when the produce was prepared for night storage. Duplicate lots that had been displayed during the daytime in the non-refrigerated case were held at night in a produce barrel and in 32° and 40°F. storage rooms.

Before they were arranged in the display cases the radishes were trimmed and sorted to remove defective parts that were apparent on careful examination of each of the bunches. Re-bunching of some lots was necessary to make the radishes sufficiently attractive for test purposes.

When the radishes were placed on the display racks, they all had an attractive appearance. However, some lots were inherently weak, as evidenced by their short shelf life when compared with others that remained attractive as much as two days longer under similar conditions of moisture and display room air and produce temperatures. The previous history of the radishes before reaching the retailer appears to have had a greater effect upon their shelf life than the method of handling commonly practiced by the retail store operators. In the tests covered by this report, some lots had become yellow, slimy, and unattractive at the end of the first day, whereas other lots remained attractive throughout the 3-day test periods.

The average daytime display room air temperatures during each of the 3-day tests were 74°, 74°, 76°, 76°, and 79°F.

The predominant defects of the radishes were yellow, wilted, and slimy leaves, and flabby or spongy roots. These defects were more prevalent in the upper layers of bunches.

In most lots, sprinkling resulted in the radish roots remaining firm and crisp throughout the 3-day tests, while the non-sprinkled roots became flabby or spongy during the second day.

Yellowing of the leaves progressed rapidly in most lots with all handling practices but was most pronounced in the non-sprinkled radishes which had also become wilted or withered.

No appreciable differences in the occurrence of decay were found between the sprinkled and the non-sprinkled radishes.

The non-sprinkled radishes lost excessive amounts of moisture with consequent deterioration in quality during each of the 3-day tests.

Produce temperatures as high as 60°F. did not materially affect the appearance of the radishes during the first day under any of the handling practices. However, after 3 days, a much larger proportion of the lots with average produce temperatures of 45°F. or lower were attractive than those with higher temperatures.

Radishes that had been sprinkled or garnished several times daily were more attractive at the end of each day of the test than were those that had not been sprinkled or garnished.



Most lots of radishes remained attractive for 1 day, but many became unattractive during the second day.

Suggestions for Retail Store Operators

Bunched radishes are one of the most highly perishable vegetables. They should be kept as cool as possible during both day and night. They may be held as low as 32°F. without injury.

Radishes that have been displayed during the daytime on non-refrigerated racks should be stored at night in iced produce barrels or in walk-in "coolers" held at low temperatures.

Because of their very perishable nature, radishes should be moved into consuming channels as quickly as possible.



